NATURE

No. 4399 SATURDAY, FEBRUARY 20, 1954 Vol. 173

CONTENTS

	Page
Scientific and Technical Man-power in Britain	321
The Study of Viruses. By F. C. Bawden, F.R.S.	324
Statistical Exercises	325
Zoological Record for 1951. By Dr. Edward Hindle, F.R.S.	325
Physico-Chemical Optics. By Dr. E. J. Bowen, F.R.S.	326
Natural History of Learned and Scientific Societies. By Prof. John Cohen, C. E. M. Hansel and Edith F. May	328
Industrial Methods of Sterilization	333
Obituaries: Prof. R. W. Wheldon. By J. S. Hall	334
Prof. H. Benndorf. By Prof. A. Székely	335
News and Views	336
Electron Microscopy Group of the Institute of Physics: Annual Conference. By Dr. C. E. Challice	340
Northern Section of the Philosophy of Science Group: Inaugural Meeting. By Dr. W. Mays	341
British Gelatine and Glue Research Association: Research Panel Meeting	342
Arab Nations Science Congress in Alexandria	342
Water Pollution Research: Report for 1952	343
The Cosmotron at the Brookhaven National Laboratory	343
Aleurone Layer in Barley	344
Forestry Commission in Scotland. By Prof. E. P. Stebbing	344
Determination of Atomic Masses by the Pykno–X-Ray Method. By Prof. T. Batuecas	345
Incorporation of 8-Azaguanine into Nucleic Acids. By Dr. Ilse Lasnitzki, Dr. R. E. F. Matthews and Dr. J. D. Smith	346
Estimation of Zinc in Biological Specimens. By T. E. Banks, R. Tupper, R. W. E. Watts and Prof. A. Wormall; R. Tupper and R. W. E. Watts	348
Letters to the Editors: Ultra Violet Irradiation of Tobacco infected with Potato Virus Y and the Availability of Virus to Aphids.—Dr. R. H. E. Bradley	350
Protein Synthesis and Genetics.—Dr. Allen S. Fox	350
Culture *in vitro* of Cambial Tissue of Cacao.—J. F. Archibald	351
Occurrence of Endosperm Haustoria in some Cucurbitaceae.—R. N. Chopra	352
Plasmodium berghei in the Placenta of Mice and Rats: Transmission of Specific Immunity from Mother Rats to Litters.—Leonard J. Bruce-Chwatt	353
Spawning Sites of Trout.—T. A. Stuart	354
A New Species of Freshwater Triclad belonging to the Genus *Polycelis*.—Dr. Eva Hansen-Melander, Mrs. Yngve Melander and Dr. T. B. Reynoldson	354
Breeding of Mice at −3° C.—S. A. Barnett and Brenda M. Manly	355
Occurrence of the Lancelet in Haifa Bay, Israel.—E. Gottlieb	355
ABO Groups in Blood Platelets.—Dr. J. Gurevitch and D. Nelken	356
Hypoglycin A, B: Biologically Active Polypeptides from *Blighia sapida*.—Prof. C. H. Hassall, K. Reyle and Dr. P. Feng	356
Genic Equilibrium of Microcythæmia in some Italian Districts.—E. Silvestroni, I. Bianco, G. Montalenti and M. Siniscalco	357
Formation of Nitrite from Oximes and Hydroxylamine by Micro organisms.—Dr. H. Lees, J. R. Simpson, H. L. Jensen and H. Sørensen	358
Electrophoretic Behaviour of Hyaluronidase.—Antonio Caputo	358
Non-participation of Folic Acid in the Biosynthesis of Methyl Compounds from Precursors.—Prema Fatterpaker, Urmila Marfatia and Prof. A. Sreenivasan	359
Density of Visual Pigment in the Frog Retina.—G. B. Arden	360
Spectrum Intensities and Radio Frequency Noise in a d.c. Hydrogen Arc.—Dr. S. E. Williams and V. Maslen	361
Shadow Microscopy for Measurement of Height.—H. H. Watson	362
Two Half-shade Devices for Optical Polarizing Instruments.—F. H. Smith	362
The *Kappa* Effect.—D. R. Price-Williams	363
A Nickel–Gallium Superlattice (Ni_3Ga).—W. B. Pearson	364

Editorial and Publishing Offices of "NATURE"
MACMILLAN & CO., LTD.,
ST. MARTIN'S STREET, LONDON, W.C.2.
Telephone Number: Whitehall 8831. Telegrams: Phusis Lesquare London

Annual subscription £6, payable in advance, postage paid to any part of the world

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Telephone Number: Regent 3891

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SCIENTIFIC AND TECHNICAL MAN-POWER IN BRITAIN

IN recent years it has been increasingly recognized that the research associations in Great Britain have an important part to play in technical and technological education. In part this arises out of the greater emphasis which has been placed on their function of securing the greater utilization by industry of existing knowledge. From one point of view this is an educational function; but the research associations can also to some extent help in providing the industries they serve with trained scientific and technological staff. The university-trained scientist may frequently thus acquire the technical knowledge or technological skill which he might find it less easy to acquire in the smaller firm.

There are at present strict limits to what is possible in this way; but the movement of staff from the research associations into industry, and especially if there is some reverse flow, could materially contribute to the fuller staffing of industry with technically trained men able to appreciate the significance of new knowledge and apply it to productive purposes: it could also help to bring the research associations into more intimate touch with industry. The possibilities here may well deserve closer study than they have yet received, and it is therefore appropriate that the role of the research associations in technical and technological education should have been the subject of a private conference in London on November 27, attended by the Advisory Council for Scientific and Industrial Research, the chairmen and directors of the research associations and some representatives of the universities and technical colleges. Discussion at this conference ranged over a wide field, but was concerned with the relations between the universities and technical colleges and the research associations, rather than between the latter and industry.

Special stress was laid on the value of experience with a research association in providing the graduate with the opportunity for extending his background and gaining appreciation of the technological problems of industry. If, as was asserted by some speakers, university regulations for the admission of students for postgraduate work are too restrictive, relaxation of such regulations so as to permit postgraduate studies under appropriate conditions in research association laboratories might, indeed, prove to be in the national interest, and the conference thought this should be encouraged. It was also recognized that there are possibilities in the exchange of staff and experience between the technical colleges and the research associations which might be further explored, and the conference will doubtless stimulate some further examination of the possibilities of closer collaboration generally by the bodies responsible. Meanwhile, the Department of Scientific and Industrial Research and the Ministry of Education are to arrange for fuller information about the research associations to be available to the technical colleges and vice versa.

The conference is to be welcomed as putting the research associations officially in the general scheme for higher technological education in Great Britain. No policy can now be regarded as complete which does not pay regard to the nature and the magnitude of the contribution which they could make to the training of technologists, of technicians and, indeed, of men for management. From this point of view, because the contribution of the research associations, to be fully efficient, must be interlocked with that of the universities and the technical colleges, the announcement made by Sir Ian Heilbron about the new financial arrangements for the Department of Scientific and Industrial Research is welcome and important. The greater flexibility which the Department will enjoy in planning its educational work, as well as its research, now that unspent monies are no longer to be surrendered at the end of the year, should enable the research associations to plan such developments with the continuity which the quinquennial grants policy has long permitted to the universities.

This is probably the most important feature of the change of Government policy towards the Department which Sir Ian announced. It means that neither a particular research association nor the Department in general need hesitate in future in embarking on some promising research or development which requires more than a year of continuous work before valuable results can be expected, for fear that Government decree would impose financial stringency. It should facilitate both the recruitment of scientific and technical staff of higher calibre and also the interchange of staff with industry and the universities, which was recognized by the conference to be so valuable.

Such consequences, with the interlocking of the work of the research associations and of the Department generally with the whole effort of Britain in scientific and industrial research and in higher technological education, may well be far more important than the actual expansion of the Department's work on which Sir Ian laid considerable stress. With rising costs, the further £6 million expected to be available for new building over the next five years is unlikely to go much further, if so far, as the £1 million a year which it was estimated in 1945 would be required for capital expenditure. Much the same may well apply to the additional £800,000 which the research associations are to receive from the Treasury over the next five years, bringing the Department's contribution from about £1,333,000, out of a total of some £4 million in 1952–53, to about £1,680,000 in 1958–59, when the Department's total expenditure, including about £4,500,000 on its own research establishment, will exceed £6 million a year.

However, although these increases may be less substantial than they seemed at first hearing, and the actual scale of research is unlikely to be increased greatly, the risk of waste of effort and frustration has been greatly diminished, and anxieties expressed in the last two reports from the Advisory Council for Scientific and Industrial Research should be largely removed. Effective planning of research on reasonably firm budgeting expectations for several years ahead becomes possible, and the execution of the Department's post-war plans for expansion should bring the scientific needs and resources of Britain into a more satisfactory relation. The basis at least is provided for consolidation as well as for expansion.

It is not only in the field of technical education, however, that the work of the research associations in particular, or of the Department in general, requires consideration in relation to the country's resources and effort in other fields. The new proposals, for example, mean that the Department will recruit yearly a further one hundred and fifty non-industrial and about fifty industrial staff, and will thus be competing further with industry and the universities for the present inadequate supply of science graduates. This is a further reason for early action for dealing with the shortage of science teachers in schools upon which any increase in the supply of science graduates depends. Something much more than the minor suggestions of the report of the National Advisory Council on the Training and Supply of Teachers will be required if the Department is not to find its plans for expansion during the next five years hindered by difficulty in recruiting staff. The Department is as deeply concerned as industry itself with the shortage of science teachers.

It is equally important that an attempt should be made to assess the magnitude and distribution of the nation's research effort in relation to its resources—both in materials or in man-power. One reason for welcoming the Government's proposal to transfer the control of the development of atomic energy from the Ministry of Supply to the Atomic Energy Corporation under the Lord President of the Council is that, provided the Lord President has the requisite staff for his extended functions, a comprehensive review of that effort and those resources should be possible at Cabinet, rather than departmental, level. That much was appreciated by at least some of the speakers on both sides of the House in the debate in the Commons on December 10; but it was equally clear that other members of Parliament have little understanding of what is involved. The arguments against the Order in Council which gives effect to the transfer of functions were ill-judged and, as Viscount Hinchingbrook and Sir David Eccles had little difficulty in showing, largely irrelevant. The really important point was missed. That the present Lord President happens to be in the House of Lords may be fortuitous, as Sir David Eccles said: the magnitude of his scientific and his financial responsibilities are now such, however, that concern can reasonably be felt that there should be no direct spokesman in the House of Commons.

It is not the transfer of functions that is open to question on scientific, technical or administrative grounds, but the tactical omission to provide an appropriate direct spokesman in the House of Commons. The point is one to which the Government should give further attention, and it might well be examined by the Parliamentary and Scientific Committee. So much depends on public confidence,

especially in fields where security reasons hinder anything like full public discussion, that a Government gesture here could do much good. As it stands, that confidence must be earned by the vigour and efficiency with which the Government concerts its policy over the whole field of science and technology. The Lord President of the Council is now in a position to concert an adequate policy. It has yet to be seen whether he has the will and determination to secure the effective implementation of his policy.

Such a policy has two main aspects. One is that of materials and finance. It is this economic aspect that has received most discussion; although, because of the extent to which the expenditure of finance and materials on defence purposes overshadows such expenditure for civil purposes, public discussion here is most hindered by security considerations. A major advantage of the new arrangements for the development of atomic energy is that they bring into the area of public discussion a large segment of the expenditure previously included under the vote of the Ministry of Supply and reaching some £150 million for "Research and Development" in 1952–53. Even if it is still not possible for the headings to be broken down in detail, it should be possible for the nation to gain some rough idea of the relative effort expended on nuclear research in comparison with the total research effort, and accordingly for some independent attempt to assess whether or not that effort is out of balance.

The value of that gain cannot yet be judged fully. Meanwhile, it should be possible for the Lord President to satisfy Parliament that the weaknesses in the organization of research and development effort indicated by the Select Committee on Estimates in its third report for the session 1946–47 and the sources of overlapping and waste of effort there and in relation to defence expenditure to which the Select Committee directed attention in its reports for the session 1948–49, are being carefully watched, and that every reasonable step has been taken to secure co-operation. At a time when difficult decisions in regard to new weapons have to be taken, it is important, just because those decisions and the reasons for them cannot be made public, that Parliament should be given the fullest possible grounds for confidence that there is no administrative slackness or departmentalism hindering co-operation and the effective use of all relevant scientific and technical advance. No such reports have come from the Estimates Committee since the Advisory Council on Scientific Policy became fully operative, and fresh inquiry might be useful.

The second main aspect of policy arises at exactly that point—the use of scientific and technical manpower. This is probably at the present time the most urgent and critical aspect of Britain's whole security: defence and economic security alike turn on her resources of scientific and technical manpower and the use which is made of them. The Government's decision to allow the expansion of the Department of Scientific and Industrial Research to proceed contemplates an increase in the staff of that Department over the coming five years of about 1,000, bringing it to a total of 5,100 in 1959, when the Department should be able to cover some 95 per cent of the activities projected in the 1947–48 plans. It is not yet disclosed what further demands on scientific man-power the plans for atomic energy development will make, but the recommendation of the Advisory Council on Scientific Policy in its last report that more scientists and technologists should be employed in industry has been emphatically endorsed in various quarters.

The implications of the present situation have been brought out in the recent report of the National Advisory Council on the Training and Supply of Teachers. Dealing particularly with graduate teachers of mathematics and science, the report points out that industry is at present taking at least one-third of the annual output of men graduates in mathematics and science at first-degree level, and a good proportion of those who have just completed a period of postgraduate research. Some forty per cent take up research or postgraduate courses or university teaching, and about twenty per cent take up teaching in schools or technical colleges. Of those who obtain honours degrees, some thirty per cent enter industry or commerce, forty-five per cent take up research, postgraduate work or university teaching, and only fifteen per cent go to teach in schools or technical colleges.

The industrial demand for physicists and chemists is still strong, and, although a slackening in the demands for defence might lead to a slight easing of the position there, the unsatisfied demand from industry generally is likely to take up any surplus. Moreover, Prof. M. B. Donald has recently asserted that five times as many chemical engineers are required by British industry as the universities are producing, and Lord Simon told the Court of Governors of the University of Manchester recently that twice the number of engineering graduates now produced could be immediately absorbed by industry. There were two hundred places for engineering students in the universities and colleges of Great Britain which were unfilled last year for lack of suitable applicants. The principal of the Manchester College of Technology, Dr. B. V. Bowden, has also stated that the College could place in good positions at least twice as many graduates as it turns out in a year, and that in some of its departments there is room for thirty to fifty per cent more students.

There is thus no probability of a decreased, but rather of an increased, demand for scientists and technologists for industrial purposes in Great Britain, and especially for work which bears on the improvement of productivity or the export trade. It is in this situation that the inadequacy of the supply of mathematics and science graduate teachers, both in quantity and in quality, to meet the current requirements of schools and technical colleges has to be considered. The average annual requirement over 1955–60 is estimated at more than fifty per cent greater than the present figure, although the National Advisory Council was unable to measure the deficiency exactly from the statistics available. What is unquestionably true is that the standard of

those taking up teaching, as indicated by the degrees they hold, has fallen conspicuously, and that the fall in numbers and quality of science teachers is already affecting the number of students taking courses in science and engineering.

If, therefore, research and development, either in industry, in the public corporations or in Government departments, are not to be impeded by shortage of scientific and technical man-power, the supply of science teachers is a matter demanding urgent and careful action. Something can, of course, be done, both by industry and by the universities, to ease the present situation by looking closely at the use they make of graduates, so as to ensure that graduates are not employed on work that could equally well be done by those less highly qualified. Probably the schools have already done as much as possible to avoid waste of science graduates in classes which do not call primarily for a science graduate, though the report directs attention to the possibilities which a wider use of laboratory assistants in the schools offers.

The recent conference of industrial and educational interests arranged by the Federation of British Industries to consider the problem as it affects industry led to valuable discussion, but the over-riding need is still for a policy for scientific and technical man-power, and for this the Government must bear the main responsibility. So far as the shortage of science teachers is concerned, the Ministry of Education cannot escape censure for failure to take energetic action to deal with a situation which has long been apparent qualitatively. To the same Ministry's dilatoriness is largely due the failure to formulate even after months an effective policy for the expansion of the technical colleges. The reply of the Chancellor of the Exchequer, Mr. R. A. Butler, when pressed on this point in the House of Commons on December 8, indicated that while, at the technological level, the Government has in mind the development of at least the Manchester College of Technology as well as the Royal Technical College, Glasgow, expansion at the level of the technical colleges is also contemplated; but he gave no indication that there is to be any balanced and concerted policy.

We require, in fact, not merely an estimate of the national need for scientific and technical man-power which fills the gaps in the survey made for the Advisory Council on Scientific Policy: we need also an estimate of our requirements in regard to technical man-power. Only then will a policy for higher technological education be possible, for it must be in balance with our policy for technical education. The danger of the present piecemeal approach is that the upgrading of technical colleges for the training of technologists may be determined by sectional or local rather than national interests, and may deflect them from the vital task of training the even greater number of technicians that will be required.

An objective view of this whole situation is the first requirement. Without it there is danger that by over-rigid insistence on standards we may expand higher technological education too late and too much, while failing to expand technical education at the lower level so that industry is provided with the further two or three thousand additional students, not necessarily university graduates, which would make all the difference to technological progress. Short-term measures are required to meet the immediate situation; but they must be in keeping with the long-term measures which are required to provide the permanent steady stream of scientists, technologists and technicians which industry and government and university establishments as well as the schools will require in future.

THE STUDY OF VIRUSES

Advances in Virus Research

Edited by Kenneth M. Smith and Max A. Lauffer. Vol. 1. Pp. xi+362. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1953.) 8 dollars.

IN the preface to this book, the first of a series which is expected to appear annually, the editors comment on the wide range of periodicals in which articles on viruses now appear. Their commendable aim is to avoid this scatter, at least of review articles; but whether they will succeed only time will tell. Success will probably demand more than what politicians call 'unilateral action', and editors of other series may not automatically forgo their interests in these topical pathogens. More likely, "Advances in Virus Research" will add another to the list of publications virus workers must consult, differing from the others, however, in dealing only with the study of viruses. That the subject now has its own volume is gratifying evidence that it has 'come of age'; but less pleasing is the almost inevitable consequence that workers in it will increasingly be called by the bastard name 'virologist'.

The contents of this volume are said to indicate the scope of the series, in which "the focus of interest is to be the virus". They are: the properties of bacteriophages (H. T. Epstein); interactions between viruses and virus strains (C. W. Bennett); transmission of plant viruses by Cicadellids (L. M. Black); insect viruses (G. H. Bergold); multiplication of influenza virus in the entodermal cells of the allantois of the chick embryo (W. Henle); poliomyelitis (J. L. Melnick); purification and properties of animal viruses (D. G. Sharp); and virus nucleic acids (R. Markham).

The titles show that the series deals with viruses which infect all kinds of organisms; but they do not all accurately reflect the contents or show that the amount of detail given by different authors varies enormously. Epstein's article has a wide title covering one of the most active branches of virus research, but occupies only thirty-five pages, which include twelve sizeable text-figures; it is typical of his summary treatment that lysogenic bacteria get one short paragraph. In striking contrast, Henle's article, with the narrowest of titles, runs to eighty-two pages of unremitting text; the last paragraph starts by saying that "the foregoing sections will have amply demonstrated that the current knowledge concerning the multiplication of influenza virus is still rather limited". Fortunately the contents are more valuable than this quotation suggests, for they

go far beyond the title and cover most kinds of work on influenza virus. Melnick's article, too, has a misleading title; it is not at all concerned with poliomyelitis as a disease, but is an admirable account of current knowledge on the virus. Bennett's is probably the best account yet given of his subject; but the subject is narrower than the title suggests, for he considers only plant viruses.

Two articles deal with insects, one as vectors of plant viruses and the other as sufferers from infection. Black's can be paid the compliment of saying that many who live where leafhopper-transmitted viruses are not yet troublesome would have welcomed more detail. Bergold shows his belief that viruses are organisms by being the only author to give them Latin binomial names, which, incidentally, are already invalid. His apparent lack of interest in the fascinating problems raised by the survival of 'latent' viruses through many generations of insects seems unaccountable.

Markham's essay will be valued by the many pathologists who know little about either the structure or functions of nucleic acids; but it is to be hoped they will not take resistance to nucleases as 'direct evidence' that nucleic acid is held internally in viruses. It may well be, but if we reason the same way from their resistance to proteases, the protein, too, must be held internally. In attempting to cover too much, Sharp has produced a rather scrappy result, which will be useful mainly as a guide to the literature.

At the start of a series, it was perhaps deliberate policy to summarize broad subjects; but this should not continue. This volume amply shows that more satisfactory articles come from the critical examination of limited topics. In future volumes, too, references should be cited uniformly; some authors now refer by numbers whereas others use the better method of names with dates, and some list only journal references whereas others give the titles of papers.

The volume is excellently produced, with detailed author and subject indexes. In the United States the price may seem reasonable; but for the sterling area it is regrettably high. F. C. BAWDEN

STATISTICAL EXERCISES

Elementary Statistical Exercises, Part I

Issued by the Department of Statistics, University College, London. Pp. 91. (1952.) 6*s*. 6*d*. net.

Introduction to Statistical Calculations

By J. Mounsey. Pp. 351. (London: English Universities Press, Ltd., 1952.) 15*s*. net.

Statistical Tables and Problems

By Prof. Albert E. Waugh. Third Edition. Pp. xiv+242. (London: McGraw-Hill Publishing Co., Ltd., 1952.) 25*s*. 6*d*.

GOOD exercises in statistics are hard to find. The essential statistical point is apt to get lost in arithmetical calculations or in pure mathematical analysis. Artificial examples lose that contact with reality which all statistical teachers try to maintain; and examples from the real world become contaminated with practical considerations which are off the essential point. Some statistical text-books do not attempt the setting of exercises at all; and, among those which do so, there are often many trivial examples and a shortage of good solid ones on which the student may test his knowledge, his grasp of fundamentals and his technical expertise.

The volumes under notice are attempts to fill this gap. The exercises from University College, London, are based on an unrivalled experience of class-work accompanying first-year lectures to undergraduate students taking the B.Sc. (Special) degree in statistics of the University of London. They are all numerical and, broadly speaking, cover univariate theory, regression and correlation, chi-squared and significance tests, sampling distributions and quality control. A second volume is promised to cover variance analysis, experimental design, correlation, probit and discriminant analysis, and curve fitting. The book is very legibly reproduced from typescript and its price is extraordinarily low. One suggestion might very well be made: Could not future editions give the answers, or at least some of the main sums of squares and products, to lighten the burden of a teacher who sets an exercise to ten students and is presented with ten different answers?

Mr. J. Mounsey's useful little book contains about six hundred numerical exercises, but is more than a mere collection. His wealth of examples is knit together by introductory text so that the methods of calculation are explained in detail. The book is designed primarily for students in commercial and technical colleges who are preparing for examinations in statistics, and should prove very useful for that purpose. Its scope is about that of the certificate of the Royal Statistical Society—averages, index numbers, estimates of error, dispersion, lines of best fit, moments, elements of probability, binomial, Poisson and normal distributions and significance tests. There are some tables of the usual kind, and answers to the exercises are provided.

Prof. A. E. Waugh's book, now in its third edition, consists of 35 tables, a list of 137 formulæ and a set of about 450 numerical exercises for class work. Many of the tables are of the standard type; but there are one or two unusual (and useful) ones, such as a perpetual Gregorian calendar and a table of the Julian day. No answers are provided, alas, but the exercises contain an abundance of stimulating material.

Teachers and students alike should be grateful for the tedious work which has gone to the making of these collections.

ZOOLOGICAL RECORD FOR 1951

The Zoological Record

Vol. 88. Being the Records of Zoological Literature relating chiefly to the Year 1951. Edited by G. Burder Stratton. Pp. vi+592. (London: Zoological Society of London, 1953.) 120*s*.

THE appearance in November 1953 of the eighty-eighth volume of the "Zoological Record" is a notable achievement, for the editor and recorders have at last reduced the delay in publication, caused by the War, to less than two years, thereby much increasing the usefulness of the "Record". Some idea of the task involved may be gathered when it is considered that all zoological publications during the year in question have to be examined and the titles of papers abstracted and afterwards distributed

to the recorders for examination and classification, and then returned to the editor before going to the printers; and finally there is the proof reading involved in dealing with approximately fifteen thousand titles in many different languages.

The present volume follows the same general plan as previous ones for a number of decades and retains a somewhat artificial grouping of the animal kingdom. Thus the section Vermes includes such diverse groups as Platyhelminthes, Nemertinea, Mesozoa, Nemathelminthes, Annelida and a number of smaller classes. It might be an advantage to subdivide this section in accordance with some generally accepted scheme of modern classification, at least for the benefit of subscribers to separate sections.

The value of the "Zoological Record" to all zoologists increases with each succeeding volume, as it furnishes a more-or-less complete bibliography of the subject since its foundation in 1864. Its usefulness has been enhanced in recent years by the adoption of a general plan whereby some indication is given of the contents of each paper which are not always obvious from the title.

The list of titles, arranged alphabetically according to the name of author, is followed by a subject index in which the titles are grouped according to the particular aspects dealt with in the paper, and finally by a systematic index, in which all the species mentioned are listed according to a generally accepted scheme of classification.

The "Record" gives some indication of the work in various branches of systematic zoology in the number of titles in each of the eighteen sections into which it is subdivided. Volume 88 includes the following: comprehensive zoology, 437; Protozoa, 1,126; Porifera, 41; Coelenterata, 274; Echinoderma, 344; Vermes, 1,011; Brachiopoda, 211; Bryozoa (Polyzoa), 56; Mollusca, 729; Crustacea, 556; Trilobita, 78; Arachnida, 666; Insecta, 335; Protochordata, 51; Pisces, 1,088; Amphibia and Reptilia, 1,233; Aves, 2,031; and Mammalia, 1,635. In addition, 1,813 new generic and subgeneric names were recorded in 1951. It will be seen that, as usual, the greatest number of papers deals with insects, birds and mammals occupying the next two places.

Certainly, no taxonomic zoologist can afford to be without this publication, and specialists in all branches of zoology will find it invaluable in dealing with the ever-increasing amount of literature on the subject. The title-page of the "Record" carries the words "Explorate solum: sic fit via certior ultra"—a very apt quotation, for the ground is fully explored by the editor and recorders, thus making the way ahead more certain.

Edward Hindle

PHYSICO-CHEMICAL OPTICS

An Advanced Treatise on Physical Chemistry

By Prof. J. R. Partington. Vol. 4: Physico-Chemical Optics. Pp. xl+668. (London: Longmans, Green and Co., Ltd., 1953.) 80*s*. net.

THIS fourth volume of the monumental "Advanced Treatise on Physical Chemistry", like the earlier volumes (see *Nature*, **167**, 740 (1951); **169**, 46 (1952); **171**, 853 (1953)), fills the reader with astonishment and admiration for the encyclopædic knowledge, historical sense, attention to detail and mathematical powers shown by the author.

Prof. J. R. Partington has evidently collected references on physico-chemical subjects over many years. He has read these references, noted their essential points and kept them in remembrance. He has a strong feeling for the great pioneers of the nineteenth century, and his extensive reading of earlier scientific work enables him to do them full justice, and to correct with meticulous accuracy the misconceptions and omissions of text-book writers.

Being based on collections, the book has a museum-like flavour; a museum of old-fashioned type rather than those modern ones with a few well-selected exhibits under brilliant illumination. Each worker's contribution is treated as an object to be found shelf-room. Pride of place is given to those classical subjects which can be developed with rigorous elegance from first principles. More than 130 pages are devoted to Maxwell's electromagnetic theory of light, which is followed from its beginnings to its applications to complex matters of refraction, wave-surfaces in crystals, etc. Other extensive mathematical treatments are of light scattering (50 pages), polarization of light (80 pages), dispersion (16 pages) and diffraction (15 pages). These treatments are clearly presented and, because of the author's desire to bring out the contributions of individuals, are necessarily prolonged. A valuable feature is the attention directed to the varying use of symbols by different authors. The Kerr, Faraday, Cotton and Cotton–Mouton effects are discussed more fully than in any other text-book. The chemist will be grateful for this storehouse of theory, much of which is not readily accessible. The emphasis, however, is always on the mathematical and physical side, and the chemical aspects are somewhat slightly touched on. As an example, fifty pages of highly physical theory on the scattering of light are accompanied by two pages of its applications to solutions of macro-molecules, and three pages to the Raman effect. The same physical bias is present in the treatments of artificially produced double refraction, of the interference of light, and of dichroism, while the several pages devoted to Airy's spirals and radiation pressure seem to be pure physics.

The secondary objects exhibited in the book are the numerous empirical relationships between physical properties which have been put forward by lesser scientists. The author has aimed at completeness in his record, increasing its value for reference, while diminishing it for student reading. In this field he is less insistent on mathematics. About Eykman's equation he says: "although it does not yet seem to have been favoured by a theoretical deduction, unlike so many formulæ which are useless for practical applications, it is one which deserves to be kept in mind".

The least satisfying part of the book lies in its accounts of instruments and experimental methods. All the ways of measuring interference of light, refractive index, etc., are given with little indication of which a newcomer to research should choose. Only a superhuman scientist, of course, could combine Prof. Partington's range of knowledge in all branches of physical chemistry with an equal skill in all modern experimental techniques. The book will find a unique place in every scientific library and will be constantly consulted both by students and by research workers; all physical chemists who can afford a copy should obtain one.

E. J. Bowen

Stone-worker's Progress

A Study of Stone Implements in the Pitt Rivers Museum. (Pitt Rivers Museum/University of Oxford Occasional Papers on Technology, 6.) By Sir Francis H. S. Knowles, Bart. Pp. 120. (Oxford: Pitt Rivers Museum, 1953.) 15*s*.

SIR FRANCIS KNOWLES, who died last year, at one time taught physical anthropology at Oxford, and it was he who studied the Mousterian teeth from Jersey and the so-called Red Lady of Paviland. About 1919 he became interested in the techniques employed by man, both prehistoric and modern, when fashioning stone implements, and the present volume is the result of this investigation. Anyone who has tried to describe shortly and clearly the various means by which flint implements can be shaped will know only too well how difficult it is to convey in words the various processes. The so-called Clacton technique is the result of a swinging blow, but, except to a specialist, what does the expression "a swinging blow" convey? Sir Francis, for example, finds himself driven to talk about "the impulsive-pressure-plus-percussion technique". Again, the "punch" technique, so important in late palæolithic times, cannot entirely be described in a few words. Nevertheless, there is no doubt that "Stone-Worker's Progress" is a valuable book for any student to possess, for it deals with modern stone implements where the processes can be actually observed as well as with the techniques used by prehistoric man which have to be deduced. Anyone interested will knapp flint himself, using the book as a guide. In this way he will understand the descriptions and learn the various possible techniques personally. The illustrations, alas, are very poor and not at all worthy of the Pitt Rivers Museum. The illustrating of flint implements is itself a specialized technique, and it is a great pity the figures were not redrawn by someone with experience in the matter. But, none the less, the volume is to be recommended to everyone who wants to know how man learnt to deal with the somewhat intractable material at his disposal. M. C. B.

Scientific Papers Presented to Max Born on his retirement from the Tait Chair of Natural Philosophy in the University of Edinburgh

Contributed by Sir Edward Appleton, David Bohm, Louis de Broglie, Richard Courant, Albert Einstein, Pascual Jordan, Th. V. Kármán and S. S. Penner, Alfred Landé, Erwin Schrödinger, Hermann Weyl. Pp. vi+94. (Edinburgh and London: Oliver and Boyd, Ltd., 1953.) 12*s*. 6*d*. net.

THIS collection of essays, presented to Prof. Max Born on his retirement from the Tait chair of natural philosophy in the University of Edinburgh, covers a wide range of subjects, from writers in widely separated parts of the world. One of Prof. Born's important early contributions to the development of the quantum theory was the introduction of the statistical interpretation of the wave function, and it is appropriate that this and related topics are the subjects of essays from several contributors—Einstein, de Broglie, Landé and Bohm—while Jordan writes on the idea of probability in genetics. Schrödinger discusses possible relations between quantum theory and general relativity, and von Kármán and Penner discuss a problem in theoretical chemical kinetics. Appleton provides the only essay on a branch of experimental physics, on geomagnetism and the ionosphere. Two essays, one by Courant on systems of partial differential equations and one by Weyl on an analytical topic, are primarily of a pure mathematical character. Most of the essays presume some previous knowledge of their subjects, and there may not be many readers to whom these subjects will all be equally familiar; but many will find something interesting and stimulating in one or more of them. An admirable photograph of Prof. Born forms the frontispiece to the volume. D. R. H.

Statistical Design and Analysis of Experiments for Development Research

By Donald Statler Villars. Pp. xvii+455. (Dubuque, Iowa: Wm. C. Brown Company, 1951.) 6.50 dollars.

THIS book is intended to summarize, "for the busy research worker or executive", the principles of experimental design. It cannot be said to succeed. The author has tried to cover too many topics in a limited space, and understanding is further hampered by the prose style, which becomes, at times, discouragingly obscure. Nevertheless, the book has its merits: it avoids the worst excesses of the 'cook-book', despite the adoption of "a journalistic order or presentation . . . so that one may immediately start applying variance analysis to his own data", and the frequent references should greatly assist the conscientious reader.

After an elementary introduction, four chapters are devoted to experimental design and the analyses of variance and covariance; these, with supplementary chapters on "the efficiency of experimentation", "miscellaneous refinements", and the mathematics of variance analysis, comprise the bulk of the work. The discussion of the analysis of variance is generally good. Interpretation by variance components is stressed, but not followed blindly, and the circumstances in which it is appropriate are carefully described. The chapters on design are much less satisfactory. Designs of the 'split-plot' type (here called "replication degeneracy designs") are extensively discussed, and frequent warnings are given against incorrect analysis of such experiments. The section on confounding, however, contains so many mis-statements that one is led to doubt the author's own grasp of the topic, and the brief discussion of the important topic of fractional replication misses the point entirely.

Two further chapters contain short accounts of quality control and sequential methods. Extensive tables are provided. M. R. SAMPFORD

Gestation Periods

A Table and Bibliography. Third Edition. (Technical Communication No. 5 of the Commonwealth Bureau of Animal Breeding and Genetics, Edinburgh.) Compiled by J. H. Kenneth, with Additions by G. R. Ritchie. Pp. 39. (Farnham Royal, Slough: Commonwealth Agricultural Bureaux, 1953.) 7*s*. 6*d*. or 1.10 dollars.

THE appearance of a third edition of "Gestation Periods: a Table and Bibliography" in the tenth year after the publication of the first shows how much it has been in demand by naturalists, biologists and others interested in mammalian reproduction. A large number of new entries is included in this edition, many of them referring to species that had not been recorded before. Further information will no doubt be added to this most useful work with the passage of time: it includes everything recorded about the subject up to the time of going to press.

NATURAL HISTORY OF LEARNED AND SCIENTIFIC SOCIETIES

By Prof. JOHN COHEN, C. E. M. HANSEL and EDITH F. MAY
University of Manchester

OUR aim in this study is not that of the historian but is prompted rather by the question whether it is possible to detect principles, preferably quantitative, underlying the formation and growth of human associations. There are several other reasons which make the study of the growth of scientific and learned societies worth while. In the first place, it gives us a comparative measure of the development and dissemination of ideas in different branches of learning at different times. Secondly, it enables us to trace the growth of learned societies in relation to demographic, educational and technological changes. Thirdly, it provides a basis for comparing fields of interest which appear to be adequately represented by single societies with others which give rise to a diversity of groups. In the course of such inquiries matters of historical interest are bound to emerge.

Sources of Data

Our study is limited to British national societies that have survived until 1952, not with those which existed only for a time, though it would seem that the number of such is comparatively small. A list of about 220 national learned and scientific societies was compiled from three sources, "Whitaker's Almanac" for 1951, "Scientific and Learned Societies of Great Britain" (Allen and Unwin, 1951) and "The World of Learning" (Europa Publications, 1951). Nearly all the societies were included in at least two of these three sources.

Societies are described for the present purpose as learned and scientific if their aim as stated in their handbooks is to promote the study and development of a recognized branch of learning. The following types of society were excluded: those which exist solely to promote professional interests, to regulate status or to co-ordinate groups of societies for mutual support. When any of these activities is undertaken by the societies in our series, it is subsidiary to their main object of advancing some branch of learning.

A personal letter was sent to each of the societies with a request for figures of annual membership from the year of foundation onwards, the number of new members year by year, details of conditions of eligibility for membership, and references relating to the history of the society. All the leading societies and most of the smaller ones most courteously and helpfully provided adequate data. Gaps in the material were filled by consulting published records.

Birth of Societies

In the accounts given by the societies of their own origins several patterns are discernible. These patterns to some extent reflect the modes of corporate life characteristic of the period in which the society was formed. For example, in the early nineteenth century gentlemen of standing met in clubs devoted to some political, social or intellectual purpose. They enjoyed open discussion in a limited social group whose members had no need to justify their claims to membership. A society formed on this pattern at the present day would be described as a coterie.

The date when a learned society is founded is an arbitrary, if convenient, point in its history. Like the birth of a child, it marks a new phase but it is not a beginning. The society, like the infant, is first conceived and then passes through a latent phase of gestation before formal establishment.

The most common mode of generation is by the efforts of a single zealous individual. At least a third of the societies we have studied seem to have been inspired in this way. An example is the London Natural History Society, founded in 1858. That was a flourishing time for entomological societies composed of zestful collectors of specimens. As a result of a letter sent by Henry Aris to the *Weekly Intelligencer* in December 1858, the Haggerstone Entomological Society was born. The members met "at the Brownlow Arms in a spacious room over the bar, each member being provided with a long clay pipe, while the necessary refreshments were provided from below, under which soothing influences the science of Entomology was keenly pursued". In 1887 they moved to superior quarters at London Wall, abandoned pipes and pots and rechristened themselves the City of London Entomological and Natural History Society.

Another example is the Quekett Microscopical Club founded in 1865 after a proposal by Mr. W. Gibson in a letter to *Science Gossip*. The idea found favour in the eyes of the editor, who gave it his support. Early Quekett members seem to have felt that the Royal Microscopical Society was too lofty for the amateur and looked upon the Quekett Club as a kind of preparatory school for the Royal Microscopical Society. One popular feature of the Club's activities was "Gossip Night". In 1944 the Club moved into Burlington House.

Other instances are the British Bryological Society, which owed its origin in 1896 to an advertisement by the Rev. C. H. Waddell, of Saintfield, Co. Down, proposing to set up a Moss Exchange Club; the Royal Meteorological Society, which arose out of a suggestion by J. G. Tatem in the *Monthly Magazine* in 1823 and established itself after some vicissitudes in 1850; the Royal Medico-Psychological Society, founded in 1841 by Dr. Samuel Hitch, of Gloucester, who sent a letter to all doctors in "Public Lunatic Asylums"; and the Anatomical Society, founded in 1887 on the initiative of C. B. Lockwood, a surgeon at St. Bartholomew's Hospital, London. The Anatomical Society prides itself on having accepted women members twenty-two years before the Physiological Society followed suit.

Perhaps the most illustrious member of this group is the Chemical Society, born in 1841. At that time chemistry was being taught in the medical schools, the only professional chemists being doctors or those articled as private pupils to medical demonstrators in the schools. The man largely responsible for founding the Society was Robert Warington, a chemist who had been articled as a private pupil to a lecturer in a medical school. His son records that his father's task was facilitated by the introduction of the Penny Post in the previous year. The

question of admitting women members was the occasion of a long and painful struggle. Eventually a postal ballot held in 1908 yielded a result favourable to women. But the Council interpreted this to mean admission as subscribers only, and only eleven women availed themselves of the privilege.

A variant on this mode of origin is exemplified in the birth of the British Astronomical Association in 1890, from the spontaneous but independent efforts of two enthusiasts, Miss Elizabeth Brown, director of the Solar Section of the Liverpool Astronomical Society, and Mr. W. H. S. Monck, a barrister (who wrote on the subject to the *English Mechanic*). At that time there were many amateur astronomers. The Association was not intended to rival the Royal Astronomical Society but to serve those "who found the subscription to that Society too high, or the papers too technical, or who, being women, were excluded". A notable early member of the Association was a New Zealander, an "astronomical chimney-sweep", Frank Hitchings, who died in 1921, aged seventy-seven. Hitchings was a bricklayer as well as a chimney-sweep and owned a 5-in. refractor which was the largest privately owned telescope in New Zealand. He "pursued a life-long study of astronomy, and he lectured for many years; he was a fellow of the Royal Geographical Society, Canterbury Philosophical Institute, and Canterbury Microscopical Society. He was a valued contributor of records of sunspots to the B.A.A., yet his sole schooling consisted of a few weeks at a night school".

About one-sixth of the scientific societies owe their origin to a budding-off from some existing body. The Royal Astronomical Society, born in 1820, seems to have been a rebellious child of the Royal Society, and the Geological Society appears to be an offspring of the same parent. In his historical account of the Royal Society of Tropical Medicine and Hygiene, Dr. S. H. Daukes suggested that "there would seem to be some need for contraceptive methods with regard to learned and quasi-learned societies". We must be thankful that the Royal Society did not find it necessary to employ such methods.

The Biochemical Society, born in 1911, was the offspring of a kindlier parent, the Physiological Society, five years after the launching of the *Biochemical Journal*. T. A. Gardner and R. H. A. Plimmer were leading spirits. The Society began as a club with meetings always followed by dinner, unlike the parent body, which in its youth was accustomed to meetings preceded by dinners. Doubtless this change in the sequence of activities had its beneficial effects. Meetings were irregular at first. Women were not admitted as members, and there was no president. The club became a society in 1911, the year in which it purchased the *Biochemical Journal*. In 1944 the Society initiated the Biological Council, which includes the Physiological, Anatomical, Pathological and Linnean Societies and the Society for Experimental Biology.

The Royal Statistical Society enjoyed a similar kind of birth in 1834. At the third meeting of the British Association, Quetelet wished to present some statistical material but discovered that there was no suitable section. The upshot was that a number of "noblemen and gentlemen" met later in London to establish an independent society.

The remaining half of the societies seem to have come into being: (1) to launch or support a journal; (2) to preserve a library, private laboratory, a collection of specimens left as a legacy, or dispose of some fund; (3) to enable the dying spirit of a moribund group to transmigrate into a new body; (4) as a collective effort of a group of workers already in informal contact; (5) as an expression of professional defence against hostile interests.

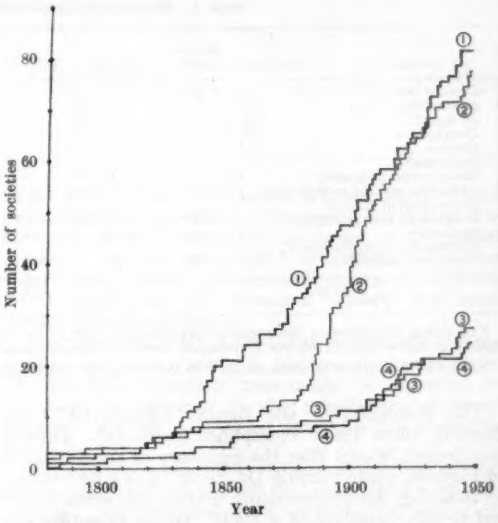

Fig. 1. Cumulative number of learned and scientific societies by date of foundation: (1) scientific societies, including general science, natural science, archæology, sociology and anthropology; (2) the humanities; (3) medical societies; and (4) technological and agricultural societies

An example of group (1) is the Society for Experimental Biology, which was initiated by the Editorial Board of the *British Journal of Experimental Biology* in 1923 partly to find financial support for the journal.

The formation of the Scottish Marine Biological Association in 1897 illustrates group (2). Its origins may be traced to a committee set up in 1894 to take over Sir John Murray's floating laboratory at Millport. The Association has changed its name three times. Another example is the Friends of the Polar Institute, formed in 1920 with the surplus remaining from the Lord Mayor's Memorial Fund for Scott.

A representative of group (3) is the Botanical Society of the British Isles formed in 1836 and descended from the Botanical Society of London, founded by Daniel Cooper.

The Royal Society of Medicine formed in 1805 is another member of this group, although its wide scope gives it a character of its own. It was originally founded as the Medical and Chirurgical Society of London, the members of which had resented "the tenacious occupation of the Presidential Chair" of the Medical Society of London by Dr. James Sims. He had occupied it for twenty-two years. The leading figures were Dr. Marcet and Dr. Yelloly, and a Royal Charter was granted in 1834. Several attempts were made to bring the chief medical societies into a single union; but there were always societies which resisted. In 1907 eighteen societies joined and the Society assumed its present title. A distinguished society which did not enter into the 1907 amalgamation is the Royal Society of Tropical Medicine and Hygiene, and another which resisted in 1912 is the Ophthalmological Society of the United Kingdom.

Table 1. Foundation of New Societies in Twenty-year Periods

	Before 1799*	1800–19	1820–39	1840–59	1860–79	1880–99	1900–19	1920–39	1940–53
General science	2		1						2
Astronomy			1			1		1	
Biology	1		2	3	3	9	8	7	2
Chemistry				1					
Physics				1	1		1	1	1
Mathematics			1		2				
Geology and geography		1	1	2	1	1	1	2	1
Anthropology and sociology				1	1	2	2	3	
Archæological studies				4	1	1	2		
Technology and agriculture	1	1	2	2	1	1	9	4	4
Medicine†	3	2	1	1		3	4	8	5
Humanities (law, literature, history, philosophy)	3	1	4	1	4	21	24	13	6
Total	10	5	13	16	14	39	51	39	21

* Including the following five societies formed before 1780: the Royal Society (1660), Medical Society of London (1773), the Royal Medical Society of Edinburgh (1778), the Honourable Society of Cymmrodorion (1751), Society of Antiquaries of London (1707).

† Dates of foundation of three societies in this group are not available.

The formation of the British Rheologists' Club (Society since 1951) exemplifies group (4). During the Second World War the secretary of the Institute of Physics, while visiting Dr. Scott Blair's laboratory at Reading, discovered many mutual interests, which led to the founding of a Club. Other examples are the Society for Applied Bacteriology, founded in 1934, and the Marine Biological Association of the United Kingdom. The latter was formed in 1884 by a group of influential people who met to establish a laboratory modelled on Dr. Dohrn's Station at Naples. Among those present at this meeting were T. H. Huxley, Sir John Lubbock and Sir Ray Lankester.

The Physiological Society, founded in 1876, is an example of group (5) and came into being in response to attacks on the work of physiologists. 1876 was the year in which Parliament passed the Cruelty to Animals Act to control the use of animals for experiments. The Act was provoked by opponents of these experiments, and it stimulated physiologists to band together to protect their interests. Another example of this type is the Research Defence Society, founded in 1908 to combat the four anti-vivisection societies existing about that time.

Special interest is attached to a society which illustrates the effectiveness of inbreeding by different generations from the same stock. In March 1897 the X-Ray Society was founded. Three months later it changed its title to the Röntgen Society. In 1902 the Röntgen Society gave birth to a child called the Electro-Therapeutic Society, limited to medical members. In 1905 this child abandoned its parent and joined the family of the Royal Society of Medicine. In 1917 the Electro-Therapeutic Society combined with the medical part of its true parent, the Röntgen Society, to form the British Association for the Advancement of Radiology and Physiotherapy. The Association changed its title in 1924 to the British Institute of Radiology, which finally, in 1927, amalgamated with the Röntgen Society.

There have been many other influences in the past, such as important events or publications, ease of transport and communication and facilities for printing, which have doubtless affected the origin and development of societies directly or indirectly. Among such varied influences may be included, for example, the Scientific Societies Act of 1843, the Great Exhibition of 1851 and Darwin's "The Origin of Species", 1859. Some early societies were necessarily limited to members living within a radius of thirty miles from the society's headquarters.

During the eighteenth and early nineteenth centuries novel problems thrown up by local industries stimulated much scientific activity in provincial centres. Many "little clubs or coteries of scientific and literary men" flourished. There were groups, for example, at Liverpool, Warrington, Bristol, Norwich, Manchester and Birmingham, which exerted a considerable influence on the development of scientific ideas. The Lunar Society of Birmingham, the members of which were popularly known as the "Lunatics", counted among its members Boulton, Watt, Erasmus Darwin, Wedgwood and Priestley, and "the meetings were appointed to be held monthly at the full of the moon, to enable distant members to drive home by moonlight".

Some of the Scottish societies of this period were distinguished by the conviviality of their proceedings. The Harveian Society of Edinburgh, founded in 1782, was preceded by a Faculty Club comprising a group of imaginary physicians who wore wigs and gowns at their meetings. The Society (which was for a time known as the 'Circulation') met annually on the anniversary of Harvey's birthday "to commemorate the discovery of the circulation of the blood by the circulation of the glass". Membership was limited to those proposed at the Aesculapian Club or the Dissipation Club. Dr. Andrew Duncan, the first president, in the conviction that medical men did not take sufficient exercise, established the Gymnastic Society in 1786, where Harveians were to compete with one another at swimming or other sports; but "enthusiasm for this detracted from attendance at

Table 2. Number of Societies and Membership

	Number of societies	Membership*
General science	5	7,900
Natural sciences		
Astronomy	3	5,100
Biological sciences	35	27,200
Chemistry	1	9,100
Physics	5	7,300
Mathematics	3	5,500
Geology and geography	10	15,100
Anthropology and sociology	9	13,200
Archæological studies	8	6,700
Technology and agriculture	25	117,000
Medicine	30	24,100
Humanities		
Law	7	6,000
Literature and language	31	39,000
Historical studies	33	25,600
Philosophy	6	4,400
Total	211	313,200

* The figures are given to the nearest hundred

Table 3. Societies in Relation to Population

Year	Estimated population of Great Britain (millions)	Estimated total membership of scientific societies	Total number of scientific societies	Mean membership	Membership per million of population
1850	20·8	6,700	17	394	322
1900	37·0	28,100	42	669	759
1952–53	50·0	89,200	74	1,205	1,784

the Harveian Festival". Among Harveian office-bearers were a Poet Laureate and a Pontifex Maximus. Members were awarded a "Doctorate of Mirth or Merriment" in recognition of "the zest with which they joined in the festivities".

Present Position

Units of measurement. Inspection of the data suggested the use of four units of measurement, namely: (1) the number of societies founded in any period; (2) the number of societies existing at any given time; (3) the age of societies; and (4) size of membership in single societies or groups of societies.

Foundation of societies. Our data relate to national learned societies, of which 134 are scientific, technological or medical, and 77 which are concerned with the humanities. The number of societies founded in each twenty-year period since 1660 is shown in Table 1. It will be noted that the latest period relates to thirteen years only.

A word is needed to explain some of the categories in Table 2. General science includes the Royal Society, the Royal Institution, the British Association, the Scientific Film Association and the Bureau of Scientific Research. The group of biological sciences includes anatomy, physiology and psychology. Historical studies includes history of science, engineering and religion.

Number of members. The membership of each group of subjects as shown in Table 2 was obtained by adding the latest available figures of members of the individual societies; and they relate mostly to 1952–53. An individual may, of course, belong to more than one society. The group figures therefore do not indicate the number of persons. The size of seventeen societies was estimated by taking the mean of their respective groups.

Societies vary in conditions of their eligibility for membership. Some of the more specialized societies, particularly in medicine, restrict members to those having specific qualifications. For example, the British Orthopædic Association, formed in 1918, originally required candidates for membership to submit a thesis. A few societies limit the size of the society regardless of qualifications. In other cases the limit seems to be raised as it is approached. The experience of the British Pediatric Association shows that abolition of a limit is not necessarily followed by an increase of membership.

Trends in the Growth of Scientific Societies

The main body of the present national scientific societies began to come into existence after the Napoleonic wars. In 1819 only four of the scientific societies in our series were in being. The number in existence has increased steadily since 1850. But the rate of formation of new societies does not seem to have kept pace with increase in membership of the combined societies. During the past century, membership has increased about thirteen times as compared with a four- or five-fold increase in the mean membership of societies. The period since 1880 has shown a great increase in biological and medical societies. Of the sixty-eight established since that date, twenty-six are biological and twenty medical. No mathematical or chemical society has been formed during the period.

Over the past 150 years there has been a steady increase in the combined figures of membership. The increase is greater than might be expected on the basis of increase in the population of Great Britain. Figures at 50-year intervals are shown in Table 3.

The figures in the table include archæological and anthropological societies but exclude general scientific, medical, technological and agricultural societies, which together numbered fourteen in 1850, twenty-one in 1900 and fifty-seven in 1950. The estimated totals for 1850 and 1900 are based on samples of eleven and thirty societies, respectively, out of the seventeen and forty-two in existence at those dates. The samples consisted of societies for which figures of membership at 1850 and 1900 were available.

When, however, we turn to individual scientific societies we by no means find an increase in all of them after allowance has been made for population increase. The Chemical and Physiological Societies, apart from a drop in the late thirties, have continued to increase in membership. Others, for example, the Geological and Royal Statistical Societies, display certain similarities which include, when allowance is made for population growth, an increase until 1880 and a steady and rather steep decline thereafter until about 1940.

The majority of scientific societies show a sharp rise in membership in the period 1940–50. The societies which show an increase over most of the period relative to population are best exemplified by the Chemical Society, which has continued to represent an entire field of science, in striking contrast to the proliferation of biological societies. This difference may be considered in relation to the nature of the subject-matter and the historical sequence of discoveries, on one hand, and to the stability of the societies, on the other.

Rates of growth. In order to compare the rates of growth of the different groups of sciences, a sample was taken of those societies for which complete series of figures were available. From 1830 onwards rates of increase over decades, after correcting for changes in the population of Great Britain, are shown in Fig. 2. Fluctuations are more pronounced in the early parts of the curves because of the relatively small number of societies which were rapidly increasing in size.

The rate of growth of membership must be due to many influences. The most obvious of these are increase in population and opportunities for higher education, which doubtless enlarge the potential membership of societies.

The curves may be studied in the light of developments in the different groups of sciences and of

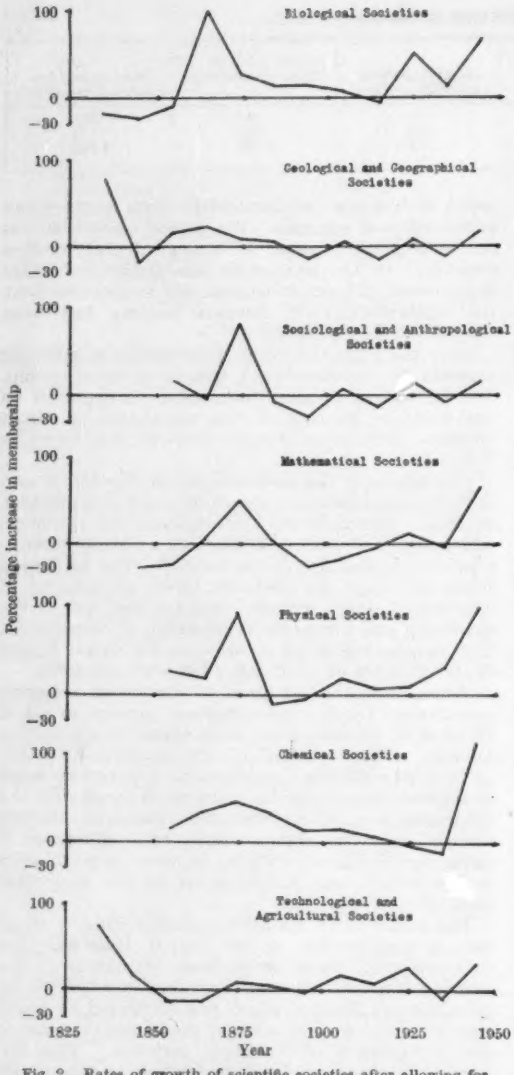

Fig. 2. Rates of growth of scientific societies after allowing for population increase

economic and social influences. For example, the large peak in the curve of the biological societies between 1860 and 1870 may possibly be associated with the publication of "The Origin of Species" in 1859. This peak is reflected to some extent in geology and geography. In the other groups of sciences a peak of growth occurs between 1870 and 1880. There is a marked difference in the effect on membership of the First and Second World Wars, respectively. There does not appear to have been a rapid increase in membership after the first war as there was after the second.

Interpretation of the Data

The collection and analysis of our data have been guided by the idea that the development of societies might show characteristics of growth similar to those displayed by cellular colonies or human populations. In particular, the interesting analogies between mental and physical epidemiology, which Prof. L. S. Penrose[1,2] was the first to draw, might lead one to expect that the growth in size of learned societies over a period of time might be susceptible to analysis in epidemiological terms. He has considered crazes, panic reactions and religious enthusiasms in the light of these analogies. The societies in our series might constitute extreme members of a class of much wider range. Intermediate members of this class might be represented by cults with pretensions to scientific status which grow rapidly and decline with the advance in knowledge as, for example, the twenty-nine phrenological societies, which once enjoyed a transient existence in Great Britain. At the other extreme are the mass phenomena of the Middle Ages, such as the Flagellant Movement and dancing manias.

The brief span of life of certain societies also characterizes certain journals. "The *Glasgow Medical Examiner* made two brief but fiery appearances with one volume published in 1831, the other in 1869. Its meteoric career was characterized on both occasions by its capacity for unrestrained vituperation against all established authority and institutions, a characteristic which, along with the yellow tint of its cover, earned for it the unofficial sub-title of 'The Mustard Plaster'. Its final taunt to its more dignified rival (the *Glasgow Medical Journal*) was a description of the article appearing there as 'a mass of clotted nonsense'."

Phases in the life of scientific societies may be expressed in epidemiological terms comparable with those identified by Penrose. First there is a latent period in which the idea of a society is germinating in the minds of one or more individuals. The second phase is an increasingly rapid growth of members.

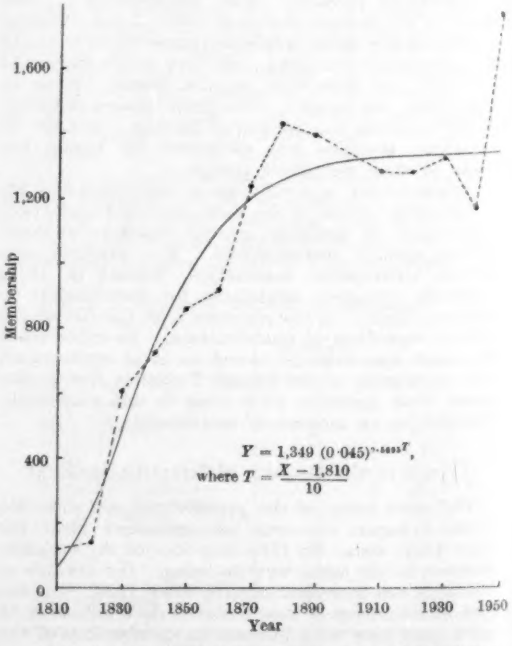

Fig. 3. Gompertz curve fitted to membership of the Geological Society

This is followed by a third phase in which the rate of growth is no longer increasing but remains fairly constant or even decreases. This may be due to exhaustion of potential membership, a factor analogous to saturation of the susceptible population in epidemiology.

During the fourth phase other influences enter, such as competing societies and shifts of scientific interest which produce immunity to the society's ideas in non-members and members alike. The development of immunity may be illustrated from the experience of one of us who joined a society about seven or eight years ago as a result of an acute 'infection' with the ideas of the society. At first the subscription was paid punctually without any prompting on the part of the society. After about three or four years, prompting was needed before the subscription was paid. At first prompting led to an immediate response. At the next stage more than one prompting became necessary and the delay became more prolonged. Eventually, the threshold of response became so high that the combined effect of several promptings was nil. There is now complete immunity.

Finally, during the fifth phase, the rate of attracting new members no longer offsets wastage from various causes. After this a society may disappear or recommence a new cycle of activity.

As might be expected, the development of learned societies seems to be subject to many more influences than is the course of an epidemic. For example, socio-economic changes and technological discoveries have a profound impact on the spread of scientific ideas and on the possibility of forming and maintaining an association.

We have fitted Gompertz curves to the figures of membership of a number of societies (without allowing for increase in population) and have found a reasonably close fit to the data. Fig. 3 shows this curve fitted to membership of the Geological Society. In the case of the Chemical Society the curve gives an excellent fit for the first eighty years of its existence. After 1920 the size of the Society fell below the expected values and at 1950 rose well above them. The curve may be used for representing stages in which a society is still growing and the size which it will reach if present conditions are maintained.

Supplementary studies and conclusion. Various independent estimates may be made of the extent of interest and development in the different fields of science in Great Britain. We have considered three types of data which could provide such estimates, namely: (1) the number of scientific journals of different kinds; (2) the number of patents sealed each year since 1852; and (3) the number of students of science in the universities.

Briefly, there seem to be two or three journals per thousand members. In the case of patents there has been a steady increase in the number sealed since 1850, comparable with the increase in membership of technological societies. During both World Wars, however, there was a distinct decline followed in each case by a recovery to the pre-war level.

The figures of university output of honours graduates in science represent perhaps the main source of potential membership of scientific societies. In 1951–52 as compared with 1925–26 the number of honours science graduates shows an increase of more than 200 per cent, advanced science students 150 per cent, and membership of societies 100 per cent.

Studies of this kind may be extended to professional, voluntary and reform societies. A special case is the growth of societies in a limited population, such as a university, where it is possible more readily to examine such problems as overlapping membership and intensity of participation. We have undertaken such an inquiry at Manchester. These studies lend themselves to elaboration on comparative lines at different levels, institutional, urban and national. For example, a comparison might be made of student life at two or more universities, or two cities might be compared with respect to the number and variety of societies of different kinds.

If size of membership of scientific societies is an index of scientific effort, the upward trend which is at present so characteristic of the figures of membership holds out promise of significant developments in the future. The trend perhaps entitles us to take a rosier view of British science in the decade ahead than recently expressed forebodings might lead one to expect.

[1] Penrose, L. S., "On the Objective Study of Crowd Behaviour" (London: H. K. Lewis, 1952).
[2] Cohen, John, *Nature*, **170**, 474 (1952).

Note. The quotations in the text are in nearly every instance taken from the literature of the societies.

INDUSTRIAL METHODS OF STERILIZATION

PROBLEMS associated with "Industrial Methods of Sterilization" were discussed on January 13 at a symposium meeting in London organized jointly by the Society for Applied Bacteriology and the Microbiology Group of the Society of Chemical Industry.

The first speaker, Dr. M. Ingram (Cambridge), discussed "Sterilization with Ozone". Ozone is widely used for air and water sterilization and for the preservation of foods, including meats and vegetables. It should be remembered that the power of penetration of ozone under such conditions is limited, and hence disinfection can take place only in the surface. The mode of action of ozone as a disinfecting agent is not understood; but it is known that it produces ozonides which in turn hydrolyse, giving rise to acid products; it also reacts with amino-acids to produce aldehydes and hydrogen peroxide. The efficacy of disinfection is therefore dependent on the nature of the material to be treated; but exact information on the influence of various factors concerned is lacking, and much of that available is contradictory. Disinfection is not achieved in time periods of seconds, as is apparently popularly imagined, but requires several minutes. A reciprocal time-concentration relationship appears to exist, provided an initial basic concentration of about 1 p.p.m. is allowed. The presence of organic matter tends to extend the disinfecting lag-period, and a similar lag occurs where the ozone concentration is low or where surfaces are being treated.

Relative humidity plays an important part in air disinfection, for increasing values above 50 per cent result in increased activity. With solutions, the

effect of *p*H is difficult to measure because of the acid products of reaction, which themselves can be inhibitory to bacterial growth. Different opinions are expressed on the effect of temperature, some authors stating that it is slight or negligible, while others find that reduction of temperature below 20° C. tends to give increased efficacy. These differences may possibly be due to errors in the methods of analysis of the ozone as well as to impurities present or to products of ozone reaction. Oxides of nitrogen, for example, which can be present in large proportions depending on the method of preparing the ozone, can exert a considerable enhancement in disinfecting efficiency.

Although the popular belief is that canned foods are virtually sterile, this is not the case in practice according to Mr. Osman Jones (London), who discussed "The Survival of Bacteria in Wholesome Canned Foods". He pointed out, for example, that foods of low *p*H value are adequately preserved by a mild heating to kill moulds, any bacteria present being incapable of development owing to the acidity. Meat products are seldom sterile in the proper sense: up to 25 per cent of certain tinned meats have been found to contain bacteria, and Savage has put this figure, in some cases, as high as 100 per cent. Tinned meats have been kept organoleptically sound for several years, although containing viable bacteria, one of the most notable examples being that of a tin of meat brought back from the Parry Arctic expedition which, on opening after 113 years, yielded six different strains of bacteria. Pork has been inoculated with *Clostridium sporogenes* and, after heat treatment, has been stored at 37° C. for long periods without showing any deterioration, in spite of the survival of small numbers of the inoculated organisms. Sudden reactions, however, have been known to take place after relatively long periods of storage, and these may be due to slow internal reactions such as nitrite – nitrate changes. Environment affects considerably the heat resistance of bacteria, and spore-formers are found to be more resistant in cooked meat than in raw material, and again more resistant if protected by fats. The reason why organisms should remain dormant for long periods is, at present, obscure.

Discussing the "Sterilization of Surgical Dressings", Dr. R. Maxwell Savage (London) directed particular attention to the different properties of superheated and supersaturated steams, stating that the former is inefficient as a sterilizing agent unless the temperature is raised to that for normal dry-heat sterilization. He illustrated diagrammatically how in steam autoclaves the normal sterilizing temperature and pressure could be attained either by a saturated steam cycle, as is usually carried out, or by a superheated steam cycle, in which case sterilization may not be properly achieved. Considerable care is necessary to eliminate air so far as possible as this tends to layer in the autoclave and also to give rise to 'superheated' steam, and so reduces the efficiency of sterilization. It also tends to layer around the surfaces of objects being sterilized and prevent full access of the steam. Moreover, air is always being introduced into the system via the steam mains supply, hence the need of adequate venting of the autoclave is apparent.

Contrary to expectations, dressings wrapped and sealed in paper present no difficulty in sterilizing. This is presumably because there is sufficient moisture in the dressings to provide steam to saturation point. Similarly, dry-heat sterilization of sealed packets can be achieved more readily in closed than open packets, again due to the small amount of steam generated through the seal. Dr. Savage agreed that air-venting of dressing drums is most important, and that there are good arguments for eliminating metal containers entirely. He also thought that one effect of superheated steam is to dry off the organisms and so render them heat-resistant.

Mr. G. Sykes (Nottingham) dealt mainly with the "Sterilization of Air" as required on a large scale for antibiotic fermentations. He pointed out that sterilization by chemical means is impracticable because of the danger of the carry-over of the disinfecting material into the fermentations, and that heat treatment, although very efficient, is again impracticable on a large scale on economic grounds. Ultra-violet radiation, although suitable for many purposes, is unsuitable in this case because of its limited efficiency both in terms of time and of its inability to deal with bacterial spores and protected organisms. The precipitron, likewise, had not proved sufficiently effective in service.

Mr. Sykes then discussed the various filter materials which are commonly used in practice, and showed that both granular and fibrous materials can be used. Efficiency of filtration depends on various factors, including the size of the air-borne particles to be removed, the size of the granules or fibres of the filter, the electrostatic properties of the filter and air flow-rate, and this was demonstrated with filter materials such as alumina, glass wool, steel wool and slag wool. These findings bear out the various theories of air filtration. A coarse granule or fibre filter is less effective than a finer one, and the packing density of fibrous filters is significant; increase of air flow-rate gives a more efficient filtration. Of the various materials tested, slag wool, as previously reported by Cherry and colleagues, was found to be the most efficient. With this material at a suitable packing-density, even after prolonged continuous use, organisms have rarely penetrated beyond about 3 in.

These papers will be published in full in the *Journal of Applied Bacteriology*, copies of which are obtainable through the Society for Applied Bacteriology.

OBITUARIES

Prof. R. W. Wheldon

Prof. Robert William Wheldon died on January 15, shortly after collapsing in his office in the School of Agriculture, King's College, Newcastle upon Tyne. His death is a severe loss to the University of Durham and to the many agricultural interests with which he was connected. He was widely known as a scientist, a farmer and a public servant.

Robert Wheldon was born in the county of Durham on January 17, 1893. He was a farmer's son and as such entered Armstrong College as a short-course student, having received his school education at Rutherford College. In this course, he showed his considerable ability and went on to take a degree in agriculture, graduating in 1915. He was immediately appointed by his professor, Douglas Gilchrist, to the teaching staff of the Department of Agriculture, and he afterwards served this Department, first as lec-

turer with Prof. Gilchrist and his two successors, and later as professor.

From the early age of eighteen he farmed on his own account and at the time of his death he occupied some seven hundred acres of farm-land in County Durham. Here, his pedigree herd of Jersey cattle hold an international reputation. However, his main endeavour was in the fields of agricultural teaching and research. His academic career was substantially influenced by his early training under Gilchrist, at a time when the experimental work at Cockle Park on grassland improvement was becoming world famous. As a member of the staff of the Agricultural Department, and later as director of the Cockle Park Station, he was responsible, in a very practical way, for much of the improved grassland husbandry techniques since applied to farming. His first personal contribution to agricultural research, however, was connected with the manuring of the potato crop, and he obtained his D.Sc. in 1927 as a result of this work.

The period 1940–53 represents a time of considerable development of agriculture within the Newcastle Division of the University of Durham. Prof. Wheldon used all his wide knowledge and experience untiringly for the furtherance of agricultural education and research. At the beginning of the War, while still a lecturer, he was appointed acting head of the Department, and gave it fresh life. He was awarded a personal professorship in 1943 and was formally appointed as professor of agriculture and rural economy in 1947. In that year, the Department of Agriculture was enlarged to a School of Agriculture with its own faculty within the University, and with Prof. Wheldon as its first dean. In 1944, the University acquired the tenancy of a 742-acre farm at Nafferton for use as a teaching farm, and in 1945 took over Cockle Park Experimental Station from the Northumberland County Council. The numbers of students and postgraduate workers increased tenfold under Prof. Wheldon's leadership.

His skill and experience were used outside the University in the application of scientific developments to farming practice, and he played a leading part in both technical and administrative work in agriculture in the North of England. During the war period, he served with the Durham County Agricultural Executive Committee and was appointed chairman of this Committee in 1952. In addition, from September 1952 he represented the Minister of Agriculture as his personal liaison officer in the Northern Province. He undertook this work although he knew full well that by doing so he was adding to the risks of ill-health.

Prof. Wheldon was a past president of the English Jersey Cattle Breeders' Society and vice-president of the newly formed World Jersey Cattle Bureau—an organization created in no small measure by his personal efforts. His old students knew Prof. Wheldon as a great friend and an inspiring teacher. Through them, his influence on the science and practice of agriculture will go on in many ways. He was a modest man and a great Christian, who enriched the experience of all who worked with him. Above all, he will be remembered by his colleagues and friends in a very personal way, especially for his kindliness and wise counsel. J. S. HALL

Prof. H. Benndorf

DR. HANS BENNDORF, professor emeritus of physics in the University of Graz, Austria, died on February 11, 1953. He was born in 1870 at Zurich and was the son of the well-known archæologist, Otto Benndorf. He studied mainly in Vienna, and he was appointed lecturer in the University there in 1899. During 1904–36 he was professor of physics in the University of Graz, where the Institute of Physics was, under his direction, a place of many-sided scientific investigations. Both the many students of physics and his colleagues knew him as a rigorous and critical yet kind-hearted teacher, always willing to give them assistance.

Of the scientific investigations of Benndorf, those in atmospheric electricity and seismometry are the best known and they were of great importance for further investigations. The Benndorf quadrant electrometer for registering the electrical field in the atmosphere is known throughout the world. Many other problems of pure physics, too, were dealt with at Graz under the guidance of Benndorf; for example, problems of the propagation of electrical waves, examination of luminescence and piezoelectricity, and measurements of ionization in electrical discharges. The great number of investigations at Graz directed by Benndorf was made possible by his genius for experimentation with limited resources, as there was little money in the Institute of Graz.

Benndorf's books and his theoretical papers, too, are distinguished by clarity of style, and he advised his co-workers to follow his example with regard to this. In the preface to the first volume of *Physica Acta Austriaca*, which came out in 1948 under Benndorf's stimulation, he urged young physicists to give a clear exposition of their work. Benndorf had the results of his investigations published only when he was absolutely sure of them, for he believed that physicists working in the same field should not have to study unnecessary literature.

The scientific work of Benndorf was acknowledged by his election as a member of the Academy of Sciences in Vienna in 1929.

Benndorf married his cousin, Rosa Wagner, daughter of the well-known political economist Adolf Wagner, of Berlin; they had four children. The eldest, Wolfgang, was until recently librarian in the University of Graz. His daughter Nora emigrated with her husband, a medical man, to the United States. Two of Benndorf's sons were reported missing in the Second World War.

Benndorf corresponded with many friends throughout the world and he also visited them, for he loved travelling. He was an ardent player of the viola in his leisure time, and was an excellent mountain climber. His strength of character and warmth of heart gave support and consolation to many in times of political stress. A. SZÉKELY

WE regret to announce the following deaths:

Mr. A. Campbell, one of the original members of the staff of the National Physical Laboratory, on February 6, aged ninety-one.

Prof. Kotaro Honda, formerly of the Tohoku Imperial University, known for his work on magnetism and in metallurgy, on February 12, aged eighty-three.

Mr. David Milne, C.I.E., formerly economic botanist to the Government of the Punjab, and during 1923–33 dean of the faculty of agriculture, Punjab University, Lahore, aged seventy-seven.

NEWS and VIEWS

Organic Chemistry at Belfast : Prof. R. A. Raphael

Dr. Ralph Alexander Raphael has been appointed to the recently created professorship in organic chemistry in The Queen's University, Belfast. Part of Dr. Raphael's schooldays were spent at Wesley College, Dublin. He graduated from the Imperial College of Science and Technology, London, in 1941 with first-class honours, and was awarded the Ph.D. degree in 1943. During the years 1943–46 he took part in the Anglo-American co-operative research on penicillin, as a departmental head in the Chemotherapeutic Research Division of Messrs. May and Baker, Ltd. He returned to the Imperial College in 1946 with an Imperial Chemical Industries research fellowship, and proceeded in 1949 to Glasgow to the post he now holds as lecturer in organic chemistry. He was awarded the Meldola Medal in 1948. The main course of his research work has entailed the study of the properties of acetylenic compounds, especially in their deployment as synthetic tools for a wide range of organic compounds of biological importance. Successful syntheses during the course of this work include penicillinic acid, histamine, linoleic acid, 2-deoxyribose, and the rare branch-chain sugars, apiose and cordycepose. Dr. Raphael's devising and carrying out of numerous ingenious and original syntheses of a wide variety of near-biological compounds gives promise of much important research work in the future. His investigations have been published in some forty research publications. He is also the author of significant contributions on alicyclic chemistry to the series of text-books on the "Chemistry of Carbon Compounds", and has been occupied in researches on tropolones. The capacity Dr. Raphael has already shown of teaching organic chemistry to students and of imparting enthusiasm for research should find fresh scope in the development of the School of Chemistry at Belfast.

John Innes Horticultural Institution : New Director

Dr. K. S. Dodds, who has been appointed director of the John Innes Horticultural Institution, Bayfordbury, Herts, in succession to Prof. C. D. Darlington, is a botanist with wide knowledge of economic plants and particular interests in the field of cytogenetics bearing on their evolution. After graduating at Armstrong College, University of Durham, he spent some time in Indiana State University as the holder of an Earl Grey Memorial Fellowship, and in 1937 joined the staff of the Imperial College of Tropical Agriculture in Trinidad. There he became interested in the breeding of bananas and devoted most of his research time for the next ten years to cytogenetical problems in *Musa*, with outstanding success in elucidating breeding behaviour in that complex and important group. He visited the Western Pacific on an official mission in 1945, and in 1947 was appointed professor of botany in the College, adding research on cacao and other tropical crops to his duties. Dr. Dodds left tropical agriculture in 1949 to take charge of the Commonwealth Potato Collection at Cambridge, now the Agricultural Research Council's Potato Genetics Station. At Cambridge his researches on potatoes and related species have been, like his earlier studies of bananas, chiefly directed to explaining breeding behaviour in a crop plant of complex genetical history.

American Association for the Advancement of Science : Awards

The Prize Committee of the American Association for the Advancement of Science announced during the recent annual meeting that the twenty-sixth Newcomb Cleveland Prize of 1,000 dollars had been awarded to Prof. Barry Commoner for his paper entitled "Studies on the Biosynthesis of Tobacco Mosaic Virus". Prof. Commoner is professor of plant physiology at the Henry Shaw School of Botany, Washington University, St. Louis, Missouri, and for some years he has been studying the changes in the metabolism of tobacco leaves produced by infection with tobacco mosaic virus. His results have led him to conclude that virus formation starts from simple ammonia compounds, and that the developing virus does not incorporate amino-acids and other intermediates that already exist in cells at the time they become infected. He considers that synthesis occurs in a series of steps, and that the virus nucleic acid is made first, to be followed shortly by a range of proteins that are not identical but are all serologically related to the infective virus. Prof. Commoner and his colleagues have previously shown that tobacco mosaic virus can be prevented from multiplying in tobacco leaves by treating the leaves with thiouracil or certain other analogues of pyrimidines and purines.

The ninth Theobald Smith Award in Medical Sciences for 1953, comprising 1,000 dollars and a bronze medal, has been awarded by the Association to Dr. Irving M. London, of the College of Physicians and Surgeons, Columbia University. This award was established in 1936 by Eli Lilly and Company. Dr. London received the award in recognition of his significant contributions in the fields of porphyrin, cholesterol, and protein metabolism. He has studied the life-span of the red blood cell in normal and pathological states, such as sickle cell anæmia, polycythæmia vera, and pernicious anæmia. Using isotopic tracers, he has developed a technique for the study of antibody formation in surviving tissue. This provides not only a method for studying the capacity of individual tissues to form antibodies, but also a controlled system for the study of protein synthesis *in vitro*.

Declassification of Atomic Information

As a result of the recommendations made by the sixth Tripartite Declassification Conference held at Chalk River, Canada, during April 8–10, 1953, amendments have been made to the Declassification Guide used to decide what atomic energy information may be published and what must remain secret. Dealing with reactors, a major difficulty in formulating policy has been that no sharp dividing line can be drawn between such power-producing reactors and reactors for plutonium production or military purposes, and indeed designs have been discussed for dual-purpose reactors for producing power and plutonium. It was agreed that while information of critical importance for the design or operation of reactors for plutonium production or military purposes must still be kept secret, information required for studies of the economics of power reactors should so far as possible be released. Up to the present, all work in production establishments, such as the Windscale and Capenhurst works, has been treated as classified. It has been agreed that many of the less important details and processes can now be released, while maintaining secret the production

technology of substances of critical importance to the project. However, in the case of heavy water and graphite production and the reduction of uranium compounds to metal, it has been agreed that some of the older production processes can now be declassified. All information on the neutron cross-sections of carbon and graphite has been declassified. The spontaneous fission-rate of plutonium-240 has been declassified. As a result of previous conferences, values for the thermal neutron cross-sections of uranium-235, uranium-238, natural uranium and plutonium-239 were released. It has now been agreed that the cross-sections may be published in the ordinary way, together with experimental details of the method of measurement. Much of the basic chemistry of plutonium has already been declassified. It has now been agreed that some of the physical properties that are related to the metallurgy of pure plutonium can also be released. Basic chemical studies involving the use of ion exchange resins for all elements except plutonium can be released, as can basic studies on the chemical kinetics of fluoride corrosion. Information can now be released on the production of fission products as sources of radiation for industrial and medical purposes.

Scientific Requirements of Pakistan

At the Sixth Pakistan Science Conference, held in Karachi during January 18–23, the presidential address was given by Dr. M. Raziuddin Siddiqi, vice-chancellor of the University of Peshawar, who chose as his subject "Scientific Research in the East". After referring to the fact that the early development of all sciences owed much to the scholars and savants of the East, who at the dawn of history were both leaders and sole workers in all branches of knowledge, Dr. Siddiqi affirmed that freedom of inquiry and freedom of expression are the two essential conditions for any kind of intellectual activity. Learning and scholarship thrive, he said, only where and when the true democratic spirit prevails, and the neglect of these conditions has been an important factor in the decay of scientific activity in the East during the past few centuries. Another factor has been the distortion of values and lack of appreciation of intellectual achievement: even now it is not generally recognized that education and research are as essential elements in national defence as armed forces, and that scientific education and research have their place in any long-range defence plan.

The immediate problem for Pakistan, Dr. Siddiqi continued, is not so much that of providing mechanics, technicians or science teachers as to produce the experts and research workers of the highest standard who can discover and develop its natural resources, build up new industries, and design and instal the plant required. An intensive search for talent among students is required and, when found, the prospective experts and investigators should be given a much longer training than is at present customary. Status and remuneration also require attention, and good work in the scientific and technical field should be sure of ample recognition. Adequate provision should also be made for fundamental research, and this is a matter of equipment as well as of personnel. Apart from strengthening the research work at the universities, well-planned and equipped scientific academies and research institutes are required, and it is also desirable to remedy the failure of the existing organization for research to produce the apparatus and equipment essential for research purposes. Dr. Siddiqi emphasized that Pakistan cannot always rely on other countries for the supply of the essential tools of research.

Plankton Studies

It is a matter of common observation that plankton is very unevenly distributed in the sea and, moreover, frequently it appears to be the case that any one patch may consist almost entirely of phytoplankton while another is mainly zooplankton. Two principal theories, not mutually exclusive, have been put forward to account for this. One, associated with the name of Harvey, is that the zooplankton would graze down a patch of phytoplankton, increasing correspondingly in numbers as it does so, until the phytoplankton is used up, and this would be followed by the dying off or migration of the zooplankton, leaving a more or less free area in which the phytoplankton could once again forge ahead. The other, associated with the name of Hardy, suggests that a high concentration of phytoplankton in some way actually repels the zooplankton and keeps it from invading the area. Richard Bainbridge (*J. Mar. Biol. Assoc.*, **32**, 385; 1953) has approached the whole problem from the experimental angle. Several ingenious pieces of apparatus made of rectangular 'Perspex' tubes, including a circular channel 4 ft. in diameter with an internal diameter $2 \times 1\frac{1}{2}$ in., made it possible to follow the migration of plankton, horizontally and vertically, under controlled conditions. An arrangement of sliding water-tight doors and admission points allowed of the setting up of phytoplankton gradients and the subsequent introduction of zooplankton. On the whole, using a fairly wide range of organisms, the evidence obtained favours the 'grazing' hypothesis, but with active and directive migration, both horizontal and vertical, playing a larger part than perhaps had been envisaged previously. In initial experiments it was found that none of the diatoms used, with the possible exception of *Nitzschia* in very high concentration, showed a toxic or excluding effect.

Activity of Fungi in Dried Soil

In relation to the very considerable work now in progress both in the fields of antibiotics and plant pathology, it is essential that fungal cultures can be stored for considerable periods of time without losing their pristine physiological properties; in particular, their pathogenicity and their ability to produce particular substances under specified conditions. In a recent paper, R. G. Atkinson (*Canad. J. Bot.*, **31**, 5, 542; 1953) has reviewed some of the methods which have been used for storing fungal cultures and has contributed new data on the survival and pathogenicity of *Alternaria raphani* after five years in dried soil culture. Soil cultures of *Alternaria raphani*, a seed-borne pathogen of radish, that had become dry when four to six weeks old, were still viable after five years. The incidence of residual viable centres in cultures of four of the five wild types studied was much higher than in those of their respective variants, on the basis of colony counts from platings of 5-gm. samples diluted one-fifth. The reverse of this was true for the remaining wild type and its variant. This pair was also unique in that the wild type had been shown to possess little infectivity, whereas its variant had proved to be highly virulent. The fungus showed no change in cultural characteristics after its five-year

period in dry soil, nor any loss of virulence when plants of radish, stock and wallflower were inoculated.

Royal Astronomical Society: Officers for 1954–55

At the annual general meeting of the Royal Astronomical Society, held on February 12, the following officers were elected for 1954–55: *President*, Dr. J. Jackson; *Vice-Presidents*, Miss Flora M. McBain, Prof. W. H. McCrea, Prof. H. H. Plaskett and D. H. Sadler; *Treasurer*, Prof. L. M. Milne-Thomson; *Secretaries*, Prof. C. W. Allen (University Observatory, Mill Hill Park, London, N.W.7) and Dr. A. Hunter (Royal Observatory, Greenwich); *Foreign Secretary*, Prof. F. J. M. Stratton.

Mineralogical Society of Japan: Officers

The following have been elected officers of the Mineralogical Society of Japan. *President:* Zyunpei Harada (Hokkaido University, Sapporo); *Secretaries:* Keiichi Omori (Tohoku University); and Toshio Sudo (Tokyo University of Education). *Treasurer:* Bumpei Yoshiki (Research Laboratories of the Asahi Glass Co.). *Editors:* Nobuo Katayama (*chief editor*), Teiichi Ito, Seitaro Tsuboi and Takeo Watanabe (University of Tokyo); Zyunpei Harada (Hokkaido University); Keiichi Omori (Tohoku University); Jitsutaro Takubo (University of Kyoto); and Toyofumi Yoshimura (Kyushu University). The Society was formed at an inaugural meeting held in the University of Tokyo on June 30, 1952. Its objects are to promote the study of mineralogy and related sciences and to bring together Japanese workers engaged in mineralogical research. Two series of publications are issued as official organs of the Society: *Kobutsugaku Zasshi* (*J. Min. Soc. Japan*), of which Nos. 1, 2 and 3 were published in September 1952, January 1953 and May 1953, respectively; and *Mineralogical Journal*, first published in September 1953).

University of Birmingham

The following have been appointed lecturers in the University of Birmingham: Dr. J. Hardwicke (experimental pathology) and Dr. J. B. Finean and Dr. W. F. R. Pover (pharmacology). The title of University Research Fellow has been conferred upon the following during the tenure of their posts as research workers in chemistry: Nadim A. Ghanem, Dr. Herbert A. Laitinen, Dr. W. G. P. Robertson, Dr. W. Brock Neeley and G. Vaughan. The following have resigned from the University: Dr. B. A. Pethica, lecturer in pharmacology, on his appointment as lecturer in the Department of Colloid Science, University of Cambridge; and G. D. Mitchell, lecturer in sociology, on his appointment as lecturer in charge of the sub-department of sociology, University College of the South-West of England, Exeter. The Gas Council has established three research scholarships, tenable for a period of three years, in the University Department of Chemical Engineering; one scholarship will be awarded each year. An expedition to the Sahara desert is being organized by Dr. E. B. Edney, reader in entomology, Department of Zoology and Comparative Anatomy, and Dr. J. Kolbuszewski, lecturer in the Department of Civil Engineering. Dr. Edney will study the ecology of desert arthropods, and Dr. Kolbuszewski will continue his studies on the wind deposition of sands. Another expedition is being made this year, the purpose of which is to study stratigraphy and palæontology in west Spitsbergen, and is being organized by Mr. P. A. Garrett, lecturer in the Geology Department, in conjunction with the University College of the South-West of England, Exeter. The University of Birmingham has made grants of up to £500 to each of these two expeditions in order to defray expenses. The Huxley Lecture of the University will be given in the Chemistry Theatre, Edgbaston, at 5 p.m. on March 5, by Dr. D. M. S. Watson, formerly Jodrell professor of zoology and comparative anatomy in University College, London.

Nuffield Foundation Awards in Dentistry, Biology and the Social Sciences

The Nuffield Foundation is offering a number of fellowships, scholarships and bursaries in the fields of dentistry, biology and social sciences as follows. The fellowships for dentistry are for persons, aged 25–35 years, with dental qualifications, to receive additional training in pure and applied science so as to undertake an academic career in dentistry, and also to enable graduates in medicine or science to receive training (not necessarily for a registrable dental qualification) that will fit them for teaching and research in dental health and disease; the fellowships are worth £500–800 a year for one to three years, and applications must be received by March 1. Dental scholarships, normally for one year only, are available for students at university dental schools in the United Kingdom and cover tuition fees and a subsistence allowance of not more than £200; applications must be received by June 30. The Foundation's scholarships and bursaries in biology and the social sciences are for graduates of British universities, preferably within the age-group 22–35 years. The awards in biology are for persons who have graduated in physics, chemistry, mathematics or engineering, but who have had no training in a biological subject, and who wish to receive such training in biology as will enable them to undertake research and teaching in the United Kingdom in biological sciences. The scholarships are for persons with some previous experience in postgraduate research in their own subject and are worth £500–600 a year (plus tuition fees); the bursaries are for those who have recently graduated and are worth £350 a year (plus fees). In both cases a marriage allowance of £50 a year and £50 for each of the first two children will be paid. Applications must be received by April 1. The awards for the social sciences are similar to those for biology, except that applications must be received by May 1 and the holder may have a degree in any subject other than the social sciences, psychology or economics; subjects suitable for study are political science, social psychology, anthropology, social statistics and sociology generally (but not economics). Application forms for all these awards and further information can be obtained from the Secretary, Nuffield Foundation, Nuffield Lodge, Regent's Park, London, N.W.1.

Semiconductors: Conference in Amsterdam

The Netherlands Physical Society, with the support of the International Union of Pure and Applied Physics and the United Nations Educational, Scientific and Cultural Organization, is organizing an international conference on semiconductors, to be held in Amsterdam during June 29–July 3. The subjects to be discussed will include bulk recombination, surface conductivity, surface trapping, surface recombination, intermetallic compounds, the

band picture in polar and non-polar semiconductors, photoconductivity in semiconductors (such as lead sulphide, lead telluride, lead selenide, zinc sulphide and cadmium sulphide) and the application of general physical and chemical laws for the preparation of semiconductors with specific properties. During the mornings, main lectures, with time for discussion, will be given and the subjects will be considered in more detail during the afternoons, when sectional meetings will be held and brief contributions of 10–15 minutes in duration may be read. The official languages of the conference will be English, French and German. The conference is open to all, without fee, on application to the secretary, Dr. H. J. Vink, Floralaan 142, Eindhoven, from whom further information can be obtained.

Tenth International Congress of Agricultural and Food Industries, Madrid

THE Tenth International Congress of Agricultural and Food Industries, arranged under the auspices of the International Commission of Agricultural Industries, will be held in Madrid during May 30–June 6. Besides reviews and discussions of a wide variety of general problems in world agriculture, food and agricultural industries, studies will be made of a number of special, or specially processed, foodstuffs. The International Commission is an inter-governmental organization, meeting once or twice a year, the purpose of which is to study scientific, technical and economic questions directly or indirectly affecting the food, agricultural and biological industries in various countries. Its headquarters are at 18 Avenue de Villars, Paris 7e. Further information regarding the Congress in Madrid can be obtained from the General Secretary of the Tenth International Congress of Agricultural and Food Industries, Zurbano 3, Madrid.

Postgraduate Course at Salford on Chromatography

A POSTGRADUATE course on both the theory and practical aspects of chromatography will be held in the Royal Technical College, Salford, during September 13–17. The lecturers will include Drs. A. J. P. Martin and R. R. Porter (Medical Research Council), Dr. S. M. Partridge (Low Temperature Research Station, Cambridge), Mr. C. S. G. Phillips (Oxford), Dr. B. A. J. Lister (Harwell), Mr. R. A. Wells (Department of Scientific and Industrial Research), Drs. A. A. Levi and R. R. Goodall (Imperial Chemical Industries, Ltd.) and Dr. G. R. Barker (University of Manchester). The fee for the course will be £4 4s. Application forms and further information can be obtained from Dr. E. G. Edwards, Royal Technical College, Salford.

Announcements

MISS PHYLLIS BARCLAY-SMITH, secretary of the International Committee for Bird Preservation, has been awarded the Gold Medal of the Sveriges Djurskyddsföreningars Riksförbund in recognition of her work for bird protection and especially with regard to the prevention of oil pollution of the sea. The Medal was presented to her by the Swedish Ambassador on February 9.

THE Aberdeen Section and the Food and Agriculture Groups of the Society of Chemical Industry, jointly with the Scottish Branch of the Institute of Biology, will hold a conference on "New Developments in the Utilization as Food of Fish and Agricultural Products and their By-products" in Aberdeen during September 30–October 2. Details of the papers to be read and the visits which are being arranged will be published in due course.

APPLICATIONS are invited for grants from the Clough Memorial Research Fund of the Edinburgh Geological Society for geological research in Scotland and the north of England (Northumberland, Durham, Cumberland, Westmorland and Yorkshire) during April 1, 1954–March 31, 1955. The Fund was founded in 1935 for the purpose of encouraging geological research and about £30 is available annually. Applications must be sent before March 31 to the Secretary, Clough Memorial Research Fund Committee, Edinburgh Geological Society, Synod Hall, Castle Terrace, Edinburgh 1, from whom further information can be obtained.

Two scholarships, tenable at research institutions in France during the academic year 1954–55, are being offered to British workers in medical science, excluding clinical medicine, by the Medical Research Council on behalf of the Centre National de la Recherche Scientifique. They are intended for young graduates in medicine or science who have already had some experience in a branch of medical science and are worth 50,000–70,000 francs a month, with a supplementary allowance, payable in sterling, for married men. A working knowledge of the French language is essential. Application forms, to be returned by March 31, and further details can be obtained from the Secretary, Medical Research Council, 38 Old Queen Street, London, S.W.1.

THE Mond Nickel Fellowships Committee is offering a number of fellowships, open to persons of British nationality with degree or equivalent qualifications, so that they can obtain wider experience and additional training in industrial establishments, at home or abroad, in order to make them more suitable for future employment in senior technical and administrative positions in British metallurgical industries. Each fellowship will cover one full working year and will be worth £900–1,200. There are no age limits; but awards will seldom be made to persons more than thirty-five years old. Application forms, to be completed by June 1, and further information can be obtained from the secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, London, S.W.1.

THE Royal Anthropological Institute has arranged six public lectures, which began on February 16 with an address by Prof. H. J. Fleure on "The English Heritage: its Study and Demonstration". The remaining five lectures will be given at fortnightly intervals on Tuesdays at 2.30 p.m. in the meeting room of the Royal Society of Arts (6 John Adam Street, London, W.C.2), the next one being on March 2. The respective subjects and speakers will be: anthropological aspects of blood-group studies in Britain (Dr. J. A. Fraser Roberts); the rural community (Prof. Adam Curle); ploughs in Britain (F. G. Paine); the importance of custom in industrial society (H. N. C. Stevenson); and the application of anthropological knowledge to our industrial society (Sir Robert Hyde). Each lecture will be followed by discussion. Admission is free. All inquiries should be directed to the Royal Anthropological Institute, 21 Bedford Square, London, W.C.1.

ELECTRON MICROSCOPY GROUP OF THE INSTITUTE OF PHYSICS

ANNUAL CONFERENCE

THE annual conference of the Electron Microscopy Group of the Institute of Physics was held in Birkbeck College, University of London, during November 10–11. The Group held its meetings in the lecture theatre of the Physics Department, and was welcomed by Prof. J. D. Bernal, head of the Department.

Papers covering the electron microscope and a wide range of its applications were read. The first paper of the conference was presented by M. E. Haine and T. Mulvey (Associated Electrical Industries, Aldermaston) on the correction of astigmatism in electron lenses. They have analysed the edge diffraction test of Hillier and Ramberg[1], showing that it is sufficiently sensitive to allow adequate correction to obtain 10 A. resolution, and they described the design and application of a four-pole cylindrical stigmator lens.

Several papers were presented covering chemical applications of electron microscopy, one of which, by E. Crampsey, Dr. M. Gordon and J. W. Sharpe (Royal Technical College, Glasgow), described an electron microscope study of the hydrochlorination of natural and synthetic polyisoprene. Miss K. Little (Medical Research Council Radiobiological Research Unit, Harwell) described how the electron beam energy could manifest itself as heat and as a source of ionizing radiation, and she showed some changes in appearance of plastics which had been bombarded by electrons from a Van de Graaff generator. Miss J. M. Peskett then described a method used in the Mechanical Engineering Research Laboratory, East Kilbride, for specimen preparation of soap fibres present in alkali base greases, whereby oil is vaporized *in vacuo* to leave the soap fibres unchanged in size, shape and arrangement for viewing in the electron microscope; the specimens are used in research into the function of the structure of a grease in the lubrication of roller bearings.

Reports of work done with the reflexion electron microscope were presented by the Laboratory of Physics and Chemistry of Surfaces, University of Cambridge, and the Research Laboratories of the Associated Electrical Industries, Aldermaston. Dr. J. W. Menter and his colleagues at Cambridge described work on synthetic and other fibres, electrodeposits and the polish on diamonds, while Dr. J. F. Halliday (Aldermaston) examined the finish of surfaces prepared by typical engineering methods, such as grinding, polishing, lapping, etc., and also worn surfaces. Some advantages of the technique are that asperities making an angle of $\frac{1}{2}°$ or less with the horizontal can be observed, and also the surface structures (such as electrodeposits) are more easily identifiable than by replica or light microscopical techniques.

A short note on some recent results of X-ray microscopy in the United States was presented by Dr. S. P. Newberry (General Electric Co., Schenectady, N.Y.) and Dr. W. C. Nixon (Cavendish Laboratory, Cambridge). Resolution using magnetic electron-beam focusing lenses was up to twenty times better than for electrostatic lenses. Micrographs obtained with magnetic focusing showed resolution of the order of 1 μ. Among the metallurgical results an aluminium–tin alloy (5 per cent tin) 0·020 in. thick showed the deposition of tin to be along the aluminium grain-boundaries.

Dr. V. E. Cosslett (chairman of the Electron Microscopy Group) and M. E. Haine (Associated Electrical Industries, Aldermaston) gave a report of the electron microscopy conference held in Innsbruck during September 16–19, 1953. This was followed by a comprehensive report by D. E. Bradley (Associated Electrical Industries, Aldermaston) on the development of a new technique for producing strong specimen-supporting membranes and also replicas of high resolution. To make the supporting films, carbon is evaporated *in vacuo* by passing a high current between two pointed carbon rods mounted so that the points are lightly held together. The evaporated carbon is allowed to fall on to the surface of glass, from which it may be stripped and mounted on specimen grids in the usual way. It may also be evaporated on to the surface of glycerol or plastic. In the latter case the plastic is dissolved away after the composite film is on the grid. To make the replicas two methods have been developed. For examining photographic grain, carbon is evaporated directly on to the emulsion, floated free on the surface of water, and mounted for the electron microscope. For metal surfaces, a plastic replica is made in the accepted manner, carbon deposited on the replicating surface, the composite replica mounted on a grid, and finally the plastic dissolved away. The carbon replica may be shadowed if desired. The carbon films produced in this way withstand the electron beam better than plastic and are more transparent to the beam. Some research done with this method was presented by J. F. Nankivell (Cavendish Laboratory, Cambridge) and E. Smith and Dr. J. Nutting (Metallurgy Laboratory, Cambridge) which supported Mr. Bradley's claim of high resolution. Dr. C. E. Challice (Wright–Fleming Institute of Microbiology, London) described how he had used the method for backing thin biological sections.

Unexpected aspects of the polystyrene – silica replica technique experienced at the Shirley Institute, Manchester, were described by S. F. Ward and Dr. D. G. Drummond. They showed that although silica, when evaporated on to the polystyrene, covers the whole surface, it remains thinner in the lee of a projection than elsewhere, producing a 'self-shadowing' effect. This effect was also shown by Mr. Bradley in his carbon replicas. A method for examining selected areas of surfaces using wet-stripped replicas was described by G. R. Booker (Metropolitan-Vickers Electrical Co., Ltd., Manchester). The selected area of surface is identified by fine scratches in the immediate vicinity, and the corresponding portion of the replica is mounted over a hole 0·015 in. in diameter in a copper disk. It is viewed in the electron microscope using a specimen screening aperture. Application of the anodic replica technique to the study of the structure of cast aluminium–manganese alloys was described by Miss M. K. B. Day (British Aluminium Co., Ltd.).

The biological session was opened by Dr. G. Eaves (School of Medicine, Leeds), who made some remarks

on the attainment of high resolution from thin tissue sections, and suggested that, to attain a resolution of 10 A., the section must be 100 A. or less in thickness. A short discussion followed in which Mr. Haine (Associated Electrical Industries, Aldermaston) stated that, to avoid graininess in the final photographic print due to random fluctuations in the electron beam, a 10-A. resolution micrograph must be recorded on the photographic plate at a magnification of not less than × 50,000. R. C. Valentine and Dr. J. R. G. Bradfield (University of Cambridge) then presented two papers, in the first of which they described how, by draining the suspending fluid from a drop of suspension on a collodion-covered grid, damage to bacterial cells can be minimized. In their second paper they described preliminary observations on 0·035-μ sections of *Staphylococcus aureus* and *Paracolon bacillus*. Bodies described as resembling chromosomes were shown in the nucleus, which was demonstrated to contain deoxyribonucleic acid by use of a modified Feulgen stain.

Dr. T. H. Flewett and Dr. G. Eaves (School of Medicine, Leeds) showed sections of egg membranes infected with vaccinia virus, ultra-thin sections of the vaccinia virus being demonstrated. Dr. E. M. Brieger and Dr. A. M. Glauert (Strangeways Laboratory, Cambridge) showed some sections of lung and spleen of mice infected with bovine tubercle bacillus.

Mrs. B. E. Williams reported that the National Physical Laboratory, Teddington, has developed a cheap method of producing gelatin copies of diffraction gratings, from which it is possible to make 'Formvar' replicas for the electron microscope for use in magnification calibration. The Laboratory is prepared to supply these copies at a nominal charge to cover postage and packing. C. E. CHALLICE

[1] Hillier, J., and Ramberg, E. G., *J. App. Phys.*, **18**, 48 (1947).

NORTHERN SECTION OF THE PHILOSOPHY OF SCIENCE GROUP

INAUGURAL MEETING

AN inaugural meeting to constitute the Northern Section of the Philosophy of Science Group of the British Society for the History of Science was held in the Staff House, University of Manchester, on January 30, at 2.30 p.m. Despite the cold weather, which made travel difficult, it was attended by representatives from the Universities of Leeds and Liverpool and the University College of North Staffordshire. Of those from the University of Manchester, eleven departments were concerned—botany, child health, classics, chemistry, extra-mural, mathematics, philosophy, psychology, radio astronomy, theoretical physics and zoology. From Leeds the departments represented were mathematics, medical physics and philosophy; from Liverpool, philosophy and zoology; and from North Staffordshire, philosophy and physics.

After Prof. L. Rosenfeld (professor of theoretical physics, University of Manchester) had been elected chairman of the business meeting, Dr. W. Mays (University of Manchester) gave an account of how the proposal for a Northern Section arose. He pointed out that for a number of years it had been felt by some members of the Philosophy of Science Group who were living in the North of England that they were missing a good deal by not being able to attend its meetings, and it was therefore considered appropriate to have a Section of the Group in their part of the country. Such a Section would help to bring together people interested in the philosophy of science and encourage discussion and research. Inquiries made at Leeds, Liverpool, Sheffield and North Staffordshire as well as Manchester showed that there was considerable interest in the proposal. The members promoting the scheme therefore decided to ask the Philosophy of Science Group for permission to form a Northern Section, and this was readily granted. As far as future activities are concerned, it is hoped to hold meetings at regular intervals at the various university centres taking part in the scheme. There will obviously have to be a good deal of flexibility and decentralization, and, wherever possible, local centres will be encouraged to organize their own activities.

The resolution to form the Section was then put to the meeting and carried, and it was decided to elect a provisional committee to take charge of affairs until October, when there will be a general meeting and officers will be elected for the year 1954–55. Prof. D. M. Emmet (professor of philosophy, University of Manchester) was elected provisional chairman of the Section, and Dr. Mays provisional honorary secretary and treasurer. It was resolved that the committee be composed of two representatives from each University, and that members should be elected by the Philosophy of Science Group on the recommendation of the Section. Twenty-eight applications for membership were made at the meeting.

Prof. L. Rosenfeld then gave a lecture on "Rationalism in Antiquity". The topic, he said, has philosophical as well as scientific implications. If one examines the atomic theory of Democritus, one is struck by the modernness of his approach as he seriously attempts to give a rational explanation of the universe devoid of theological or mythological content. The view has been advocated that the growth of rational thinking in Ancient Greece, which led to the birth of Ionian natural philosophy, was to some extent conditioned by the social and economic changes occurring at the time. During the Pre-Socratic period the Greeks had the East opened up to them for trading purposes. In some ways one is reminded of the growth of scientific ideas during the sixteenth century as a result of navigational discoveries.

With the breakdown of Athenian democracy and its subsequent domination by Alexander, Greek philosophy lost its flexibility and became rapidly systematized. A new type of literature developed, the writing of Utopias with their veiled criticism of the authorities. The seeds sown by free discussion among the earlier Greek thinkers became, in Alexandrian times, Stoicism and Epicurianism; but whereas Democritus represented an optimistic and constructive philosophy, Epicurus and Lucretius represented a philosophy of pessimism fighting against a decaying civilization.

But the ideas of the Milesian thinkers were not entirely original. The first international carriers and merchants were the Phœnicians. If the philosophical thought of the Phœnicians was purely mythological in character, the hypothesis that there is a relationship between rationalism and commercial adventure becomes considerably weakened. The little that is

known of Phœnician cosmology would seem, however, to indicate that it too was rationalistic in character. Though this resemblance between Phœnician and Greek thought may have been solely due to their both being seafaring nations engaged in commerce, one cannot entirely rule out the possibility that the former had some influence on the latter.

W. Mays

BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

RESEARCH PANEL MEETING

THE seventh meeting of the Research Panel of the British Gelatine and Glue Research Association was held at Beale's Restaurant, London, N.7, on November 26, with the director of research, Mr. A. G. Ward, in the chair.

The meeting took the form of a symposium on soluble collagens, the salient points under discussion being outlined in a general introduction, given by Dr. R. H. Smith (Biophysics Unit of the Medical Research Council). The remaining speakers then gave more detailed accounts of the progress made and conclusions reached in studies made using specialized techniques. Dr. R. W. G. Wyckoff (science attaché to the American Embassy, London) reviewed the evidence for the conclusion that the fine structure of reconstituted collagen fibrils, as revealed by electron micrographs, depends upon the conditions for reprecipitation (for example, the *p*H and the precipitating agent). At present, four kinds of order may be produced, only two of which (with spacings of 640 A. and 210 A.) have been seen in native collagen. The remaining forms are fibrils with a spacing greater than 2000 A. and segmented fibrils.

Dr. F. C. Kelly (Biophysics Unit of the Medical Research Council) described in some detail experiments on the production of segmented material by adding nucleotides (such as adenosine triphosphate) to solutions of alkali-soluble collagen, prepared by extracting rat skin with secondary sodium phosphate.

The preparation and properties of the materials obtained by the reconstitution of citrate-extracted calf skin, acid-extracted tendon and alkali-extracted calf skin were discussed by Dr. J. H. Bowes (British Leather Manufacturers' Research Association). Amino-acid compositions, determined by Moore and Stein's procedure, were compared with that of native ox-hide collagen. These results are of particular significance to the manufacturer of gelatine, who normally pre-treats the raw material under acid or alkaline conditions.

Dr. D. S. Jackson (Rheumatism Research Centre, Manchester) gave an account of recent work on the evaluation of the relative importance of ionic and hydrogen bonds in determining the stability of rat-tail tendon. About one-quarter of the stability appears to arise from ionic linkages between collagen and chondroitin sulphuric acid, the main mucopolysaccharide present in tendon.

An extensive investigation, using human abdominal subcutaneous connective tissue, has led to the conclusion that this tissue contains at least three acid polysaccharides, none of which is identical with chondroitin sulphate. Dr. R. Consden (Special Unit for Juvenile Rheumatism, Maidenhead) described the work leading to this conclusion, and Dr. J. E. Eastoe (British Gelatine and Glue Research Association) mentioned that he had found similar complexity in the mucopolysaccharides in the ox-femur shaft.

The important question of how collagen fibres arise within living tissue was discussed by Dr. S. Fitton Jackson (Biophysics Unit of the Medical Research Council), who paid attention particularly to the evidence obtained from phase-contrast microscopy and electron microscopic studies on the ossification of embryonic cartilage in the chick.

The final topic for discussion was high-angle X-ray diffraction in collagen. Mr. A. C. T. North (Wheatstone Physics Laboratory, King's College, London), after indicating the difficulties associated with obtaining reconstituted collagen in a form suitable for X-ray diffraction work, discussed the information which has been obtained from diffraction diagrams of swollen rat-tail tendon. Such diagrams are typical of a helical rather than a sheath-like structure for collagen. Dr. P. M. Cowan (also of the Wheatstone Physics Laboratory) elaborated on this conclusion, mentioning the requirements of bulk density and the importance of proline residues in connexion with hydrogen-bonding and stereochemical considerations. The helical structures proposed by various authors for collagen have been examined by the optical diffraction pattern method, and none appears satisfactory.

ARAB NATIONS SCIENCE CONGRESS IN ALEXANDRIA

A SCIENCE congress for the Arab nations, arranged by the Arab Nations Organization, was held in Alexandria, for the most part in the Faculty of Commerce of the University of Alexandria, during September 1–8, 1953, under the presidency of Prof. Mostafa Nazif, vice-rector of Ibrahim University, Cairo. More than five hundred men of science attended, representing Egypt, Iraq, Jordan, Lebanon, Palestine, Saudi Arabia, Syria and Yemen. The congress was opened by the president of the Republic of Egypt, General Neguib, who, with the official delegates from the nations participating, gave short speeches in which they stressed the importance of scientific co-operation among the Arab nations.

The activities of the congress were grouped into three sections. The first section, on original researches, consisted of about sixty papers dealing with mathematics, astronomy, physics, meteorology, biology, geology and chemistry; these papers were read before three groups, each of which held four meetings. Full details of these researches will be published in a special book to be issued by the organizing committee of the congress. At the second section, on general scientific problems, the subjects discussed dealt with scientific terminology; editing, translating and publishing books; the training and equipment of science teachers for schools; and the importance of science to the national economy. The organizing committee for the congress had previously arranged for the discussion of these problems by forwarding questionnaires to members of the teaching staff in the universities and ministries of education in the participating nations, and the replies had been published in book-form and circulated to members of the congress before meeting. The Arabic language was strongly recommended for the teaching of science in universities, and encouragement of the publication

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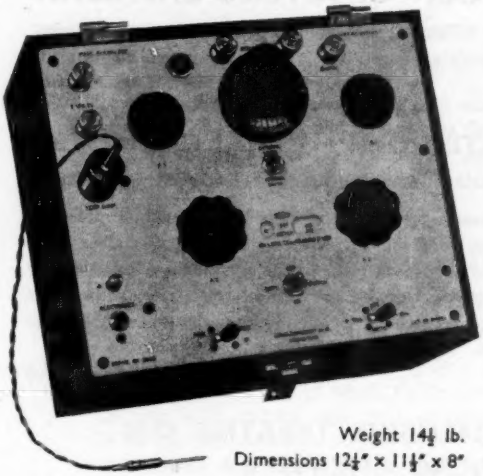

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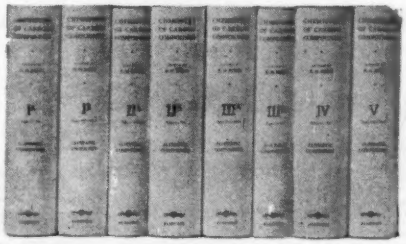

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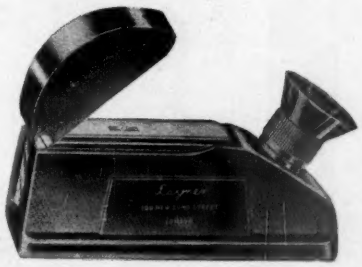

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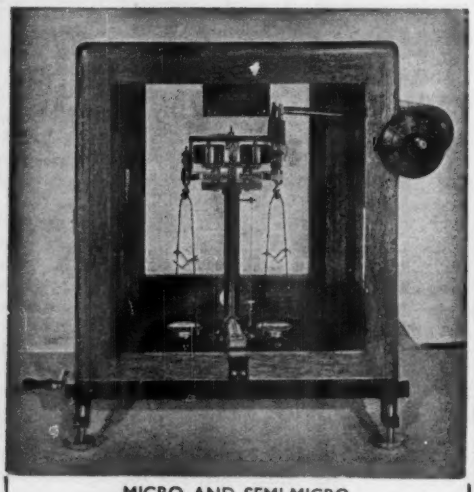

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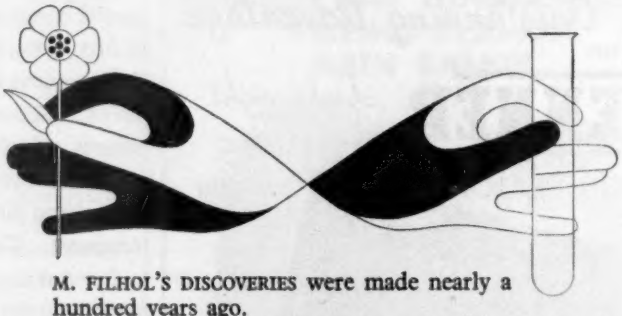

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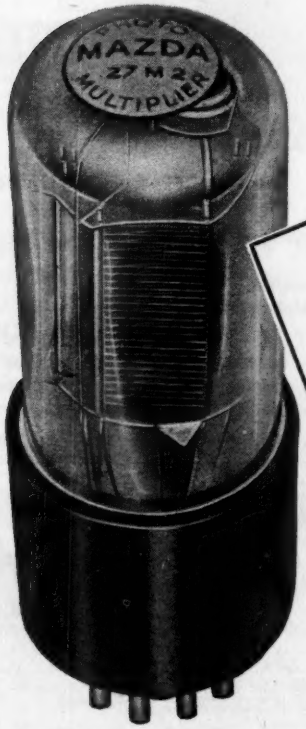

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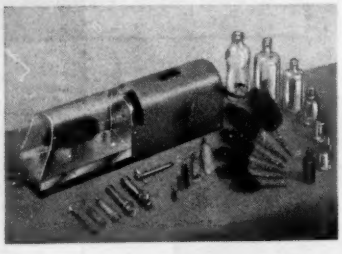

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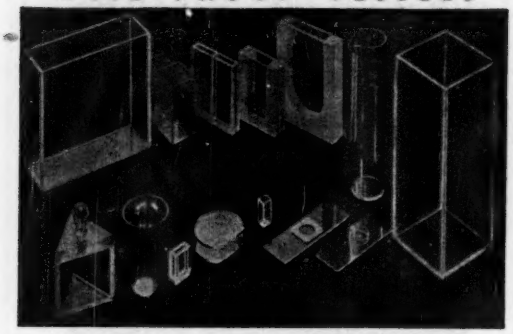

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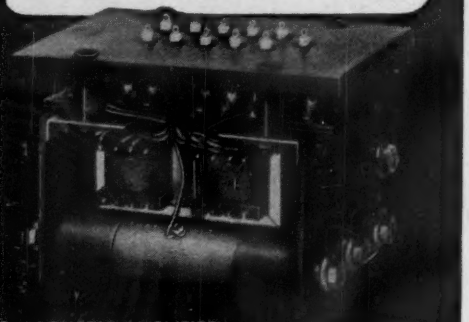

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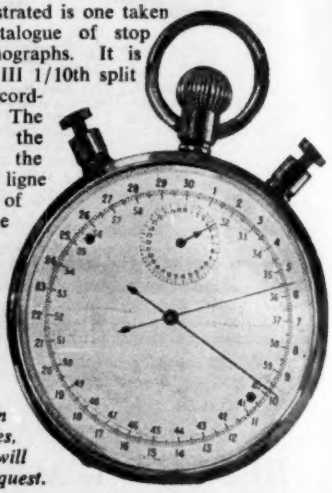

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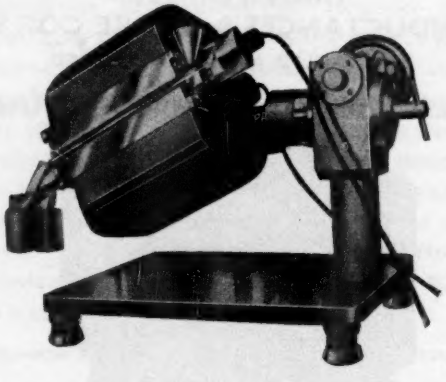

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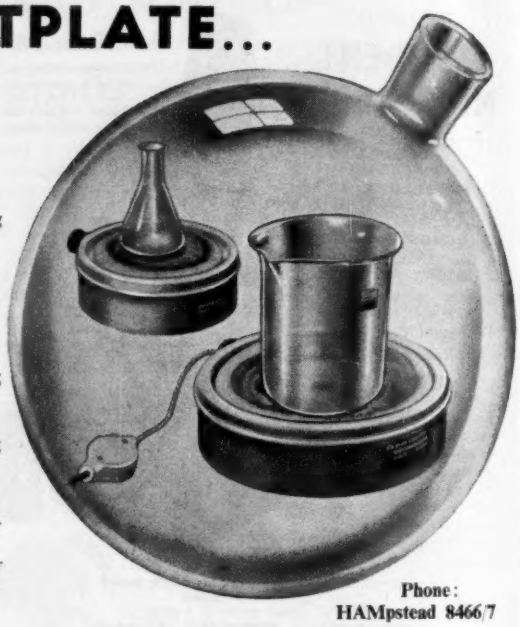

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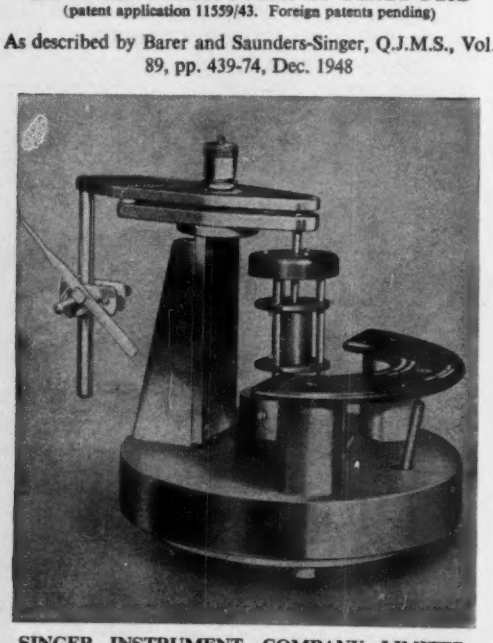

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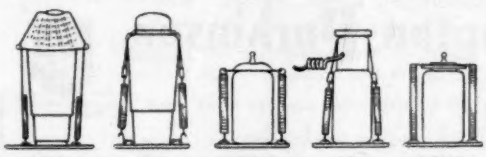

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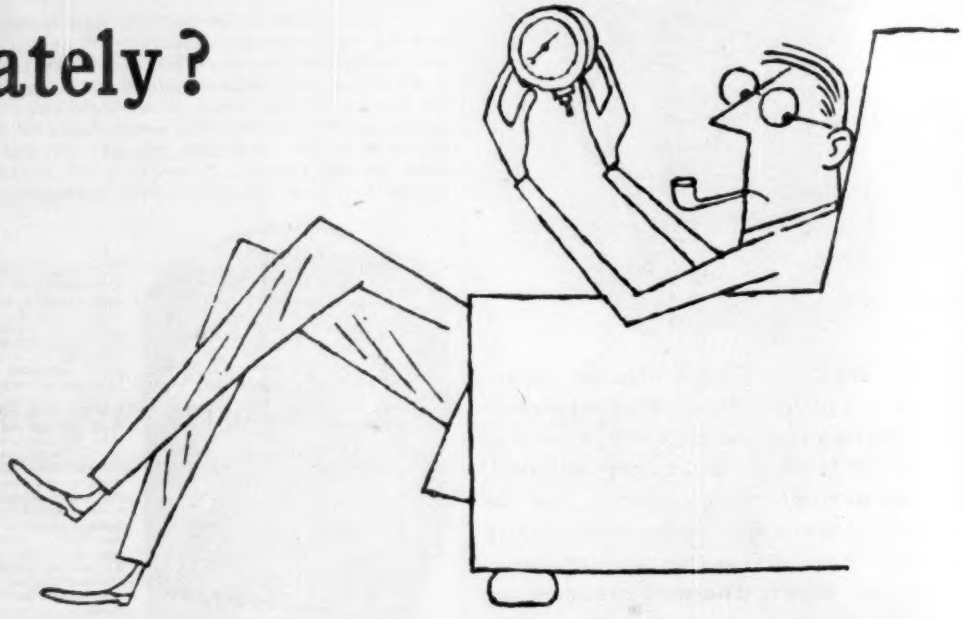

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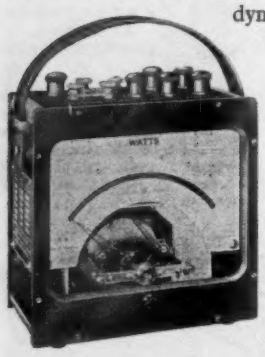

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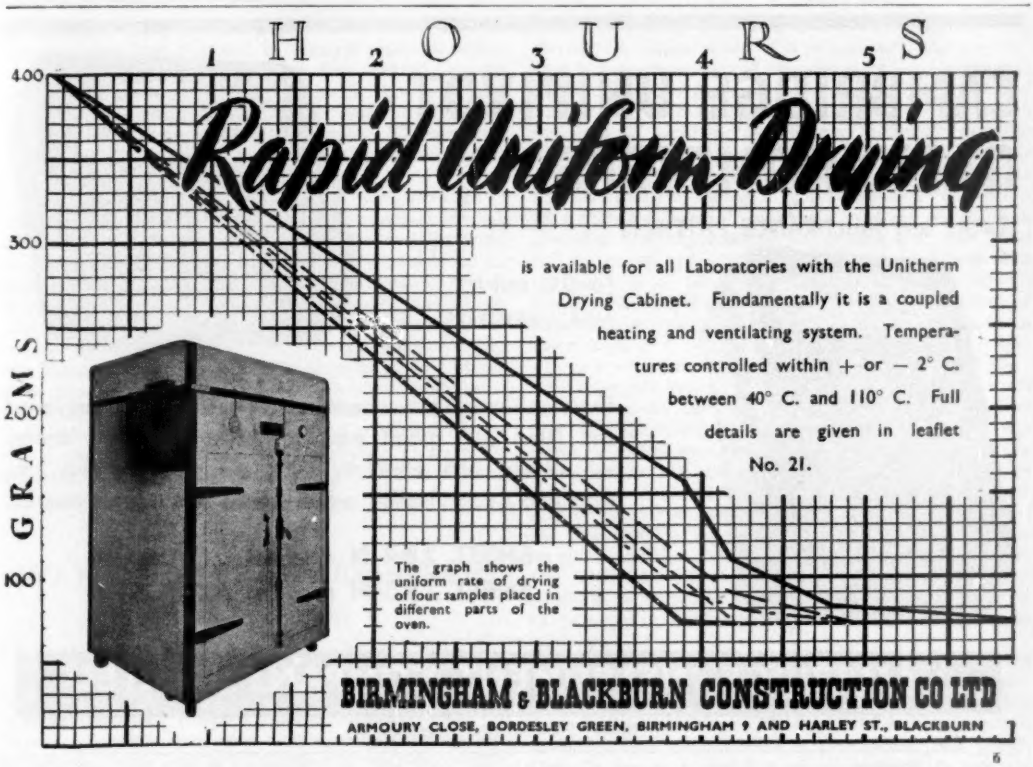

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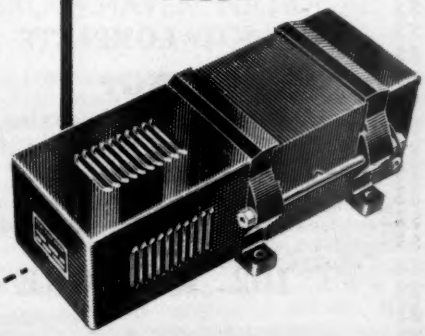

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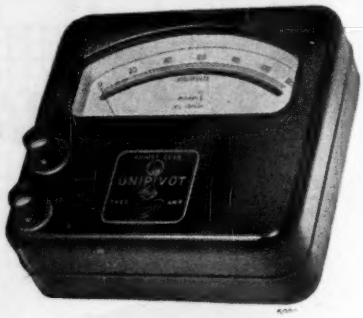

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of scientific books was stressed. The third section of the congress was devoted to general cultural talks, and the subjects dealt with in this section mainly comprised the history of science in the Arab nations, such as progress in mathematical and navigational sciences, by Kazwini, Ibn El Haytham, Khowarizmi, El Tousy, El Bayrouni, El Battani, Ibn Sena, Gaber Ibn Hayan and others.

During the congress, exhibitions were arranged: one dealing with modern materials organized by the United Nations Educational, Scientific and Cultural Organization, another with the history of science in the Arab nations, and a third with scientific books written in Arabic and other languages. The congress also arranged for visits to places of scientific interest, such as the Institute of Marine Biology at Alexandria, the Roman Museum, the Misr Company for Cotton Weaving, the Misr Company for Artificial Silk, and the Burg el Arab field for desert plants. Among the decisions made in the final meeting of the congress was a recommendation for the institution of an Arab Scientific Union to be initiated by the Arab Union Organization.

WATER POLLUTION RESEARCH

REPORT FOR 1952

THE report of the Director of Water Pollution Research and that of the Water Pollution Research Board are contained in an interesting publication entitled "Water Pollution Research 1952"*. It is not possible in a short notice to indicate all the interesting work that is being done on this important subject, and the reports themselves should be consulted.

Work has continued on the effect of various substances on the disinfecting action of chlorine on bacteria in water, and methods have been improved for the enumeration of *Streptococcus faecalis*, an organism which is one of the indicators of fæcal pollution. Work has also been done on the removal of radioactive iodine discharged as a constituent of sewage in small amounts into streams after its use in medicine.

Work on sewage at Birmingham has confirmed that slow rotation of percolating filters lowers the biochemical oxygen demand of the effluent and considerably increases its nitrification. Other work on sewage has shown that a volume of filtering medium of 10 cubic yards for each 10–20 persons gives effluents of very good quality. Experiments done in co-operation with the Gas Board have shown that spent liquor from the gasworks at Hinckley can be treated in a percolating filter in admixture with sewage, in a concentration up to 3 per cent, by volume, without causing much deterioration of the quality of the effluent. This proportion is very much higher than that possible when gas liquor of the ordinary type is used. The methods used at Hinckley for the treatment of hot gas by electrostatic precipitation, with the object of reducing the concentration of higher tar acids in the liquor, are described. Further work on this subject is in hand.

Work has also been done on industrial waste waters. In the treatment of black liquor resulting from the kiering of cotton, an active sludge has been developed which, when it is mixed with the neutralized liquor, causes rapid anaerobic fermentation with the evolution of gas containing about 80 per cent of methane. Experiments have also been done on methods of treating simple and complex metallic cyanides mixed with sewage. It has proved possible to obtain, from sewage containing potassium, zinc and cadmium cyanides in concentrations equivalent to a hundred parts of hydrogen cyanide per million, effluents which contained an average of less than 0·2 p.p.m. of cyanide. It has also been shown that the toxicity of potassium cyanide in small concentrations increases markedly as the concentration of oxygen in solution is reduced. This is important in the design of toxicity tests and in the effect on fish of toxic substances in rivers.

The largest section of the report discusses the work on the Thames Estuary. Among the subjects studied are the distribution of salt and fresh water, the effect of rough weather in raising the level of oxygen dissolved in the water, pollution by discharges of organic matter contained in streams, sewage effluents and industrial wastes, the particle size of deposits in the Estuary, the important effect of suspended solids on the biochemical oxygen demand of Estuary water, the inhibition by oxygen of bacterial reduction of sulphate to sulphide and the catalytic effect of mud in promoting oxidation of sulphide by oxygen in solution.

The presence of large quantities of foam in rivers has been reported from many places during the year, and work on this problem is contemplated. With regard to the problem of pollution of beaches by oil, investigations on methods of preventing this pollution, in which a number of oil companies are co-operating, is in progress. A special problem, not specifically mentioned in these reports, would seem to be the general effects of substances now being extensively used for the control of pests of crops. Since the end of 1952 *Water Pollution Abstracts*, published by H.M. Stationery Office, has issued 35,000 abstracts, and the size of this monthly publication was increased in 1953 to meet the large number of papers now being written in Britain and elsewhere on this subject.

*Department of Scientific and Industrial Research. Report of the Water Pollution Research Board, with the Report of the Director of Water Pollution Research for the Year 1952. Pp. iv+64+4 plates. (London: H.M.S.O., 1953.) 2*s.* 6*d.* net.

THE COSMOTRON AT THE BROOKHAVEN NATIONAL LABORATORY

VALUABLE information concerning nuclear forces and the properties of fundamental particles can be obtained from the study of the interaction of high-speed nucleons with nuclear matter and from the interaction of individual nucleons. The energies required for the production of the lighter π-mesons and the heavier mesons are known from cosmic-ray investigations, and it has been the endeavour of many workers to produce such mesons in the laboratory by means of particle accelerators. Already during 1946–47 several particle accelerators capable of producing particles with energies of 300–400 MeV., sufficient for π-mesons, were under construction; but the design of accelerators for production of the heavier mesons requiring energies of the order of 5,000 MeV. had not been investigated.

In 1947 the Brookhaven National Laboratory, Upton, New York, after careful consideration of the scientific, economic and practical factors involved, concluded that the proton synchrotron was the best type of accelerator suitable for the purpose, and in 1948, with the financial assistance of the United States Atomic Energy Commission, the design and construction of the cosmotron was commenced. The assembly took nearly four years, and in May 1952 a proton beam of 1,000 MeV. energy was obtained. This was increased to 2,000 MeV. in the following month, and with suitable modifications to the pole windings it is confidently expected that 3,000 MeV. will finally be obtained. Machines capable of reaching higher energies are being constructed elsewhere; but the cosmotron was the first high-energy accelerator to be constructed and to be operated.

The work was directed initially by M. Stanley Livingston (Massachusetts Institute of Technology), then by Milton G. White (Princeton University), and finally by G. B. Collins, who is the present chairman and who joined the project in April 1950. A detailed description of the principle, construction and operation of the cosmotron is given in a series of articles, edited by M. Hildred Blewett, a member of the cosmotron staff, in the special cosmotron issue of the *Review of Scientific Instruments* (**24**, No. 9; September 1953). L. J. Haworth, director of the Brookhaven Laboratory, contributes a short foreword, and this is followed by a general review, by the editor, of the cosmotron, discussed component by component and giving data concerning the personnel, cost and basic parameters.

A ring-shaped magnet guides the particles on a circular path of radius 30 ft., and a radiofrequency electric accelerating field provides increments of energy to the protons which are injected initially into the cosmotron, at about 3·5 MeV., from a Van de Graaff accelerator. The maximum magnetic field is 14,000 gauss. The vacuum is maintained by twelve 20-in. diffusion pumps at a minimum operating pressure of 5×10^{-6} mm. of mercury, and the volume evacuated is about 300 cu. ft. The other articles in the series are divided into sections dealing with the magnet, the pole-face windings, the radio-frequency system, the injection system, the vacuum system and the control system, respectively. Finally, three short papers deal with the cosmotron building, eddy-current phenomena and studies of injection phenomena in the cosmotron, respectively.

ALEURONE LAYER IN BARLEY

In a comprehensive anatomical investigation of the aleurone layer in the cultivated barley, J. Sawicki (*Polska Akademia Umiejetnosci*, No. 66, 1–59, pub. Krakow, 1952, with English summary) has examined 103 varieties, representing all the sub-species of *Hordeum sativum* collected in different parts of the world.

In these materials, the number of cell rows in the aleurone layer and its thickness were observed. The range of variability of these characters was studied to see if they could be used in the classification of barleys. The hereditary transmission of these characters was also investigated over a period of several years. It has been ascertained that the varieties examined show distinct differences in regard to both the characteristics studied. The mean number of cell rows in the aleurone layer of the different barley varieties ranges from 1·64 to 3·11, and the mean thickness of the aleurone layer from 49·94 to 110·16 microns.

Observations of the two characteristics in question on material from several years and from different climatic conditions showed that they exhibit a comparatively small variability due to the environmental conditions. A detailed analysis of variance of material of forty varieties from 1937, 1938 and 1947 cultures showed that as regards the number of the cell rows the varietal differences are responsible for 93·00 per cent of the total variation and for 85·60 per cent as regards thickness of the aleurone layer. The variation due to seasonal differences is very small: in the first case 0·60 per cent, and in the second 0·40 per cent of the total variation. The remaining amounts of variation are due to unknown causes (environmental changes). Similar results were obtained by analysis of the variation of the pedigree lines from 1947, 1948 and 1949, indicating that there are no essential differences between the pedigree lines and the examined material of commercial varieties. The results obtained justify the view that the aleurone characters are comparatively constant and may therefore be used in classification.

It is held that the results of these investigations corroborate the earlier data of Orlow, who found that barleys endemic in the Asiatic centre of origin as a rule possess three rows, and those of the African centre two rows, of cells in the aleurone layer only. As the European varieties of cultivated barley show a similar differentiation, the possibility exists of explaining, in some cases, their primary origin.

FORESTRY COMMISSION IN SCOTLAND

In a small illustrated pamphlet entitled "The Forestry Commission in Scotland" (recently published by the Forestry Commission) it is stated that the history of forestry in Scotland is a long one. Shakespeare in "Macbeth", for example, brought the Birnam Woods to Dunsinane, a difficult military position, and timber from the same Birnam Hill in Perthshire was used for helping the national effort during the Second World War. Great natural woods once covered most of Scotland; but through the years, fire, disease and the axe took a great toll. Later, many of the remaining forests were exploited for charcoal for iron-smelting purposes, followed by the spread of sheep-raising at the end of the eighteenth century.

It was the great inroads into the woods of the country, almost entirely privately owned, during the First World War that brought the Forestry Commission under the Forestry Act of 1919. The Commission was reconstituted by the Forestry Acts of 1945 and 1951. Under the 1945 Act the Commission was made subject to direction from the Minister of Agriculture and Fisheries and the Secretary of State for Scotland. In Scotland all land acquired through the Forestry Fund is vested in the Secretary of State.

Between the World Wars a great deal of planting was done by the Forestry Commission, but the resultant plantations were still too young to provide any contribution of value to the timber requirements of the Second World War. Once again it was the

privately owned woodlands which were subjected to over-felling, no less than 344,000 acres being felled. In Scotland this war-time felling amounted to 155,000 acres, with the result that many a glen and mountain-side are now no longer recognizable.

In 1946 the Commission embarked on a big post-war programme, the aim of which is to produce five million acres of productive forests in Great Britain. This involves the development of three million acres of new forest mainly on moorland and mountain-side and other land of low agricultural value, and the restoration to full production by private owners and the Commission of two million acres of existing woodlands. It is proposed that not less than half the new planting will be carried out in Scotland, where there is a great deal of land eminently suitable to afforestation, this being done without any interference with land which can be utilized for agriculture, for agriculture has the first call on all land.

Planting is proceeding all over Scotland at a steadily increasing rate. During the 1951–52 season nearly 31,000 acres were planted by the Commission, whereas five years before only about 12,300 were planted. By 1956 it is hoped to increase the annual rate to forty thousand acres, about 40 per cent being in the Highland counties. The Commission has one million acres of land in Scotland, three hundred thousand acres of which is planted; the balance of the land is made up of areas still being grazed and awaiting afforestation, land given up to forest nurseries, unplantable land and mountain tops the forests of which come into the national forest parks, and lastly a considerable area which will remain permanent agricultural land. Among the species of tree used, Scots pine ranks high; but on the peaty slopes of the western hills, with their high annual rainfall, Sitka and Norway spruces are more satisfactory. Other conifers used are the three larches, European, Japanese and hybrid, the Corsican pine and the Douglas fir, the latter first introduced in 1826 from British Columbia by David Douglas. The area suitable for hardwoods is limited. Already the work entailed has resulted in an increase of population, and forest villages are in the process of being built. The afforestation campaign will add in the future very considerably to the wealth of Scotland, apart from the increase in employment provided by the forests and the connected wood industries.

E. P. Stebbing

DETERMINATION OF ATOMIC MASSES BY THE PYKNO–X-RAY METHOD

By Prof. T. BATUECAS

Laboratory of Physical Chemistry, University of Santiago de Compostela, Spain

In a previous communication[1] it was shown that the atomic masses of various chemical elements can be calculated with precision by means of the pykno–X-ray method, when the density and X-ray data of the crystalline solid have been measured at the same temperature.

It is to be noted, however, that the method as described was not capable of the highest accuracy because the data used were slightly uncertain. In order to remedy this and at the same time to check the accuracy of the new method, researches have been in progress since 1950 in this laboratory with the object of measuring the densities of several crystalline solids at the same temperature at which their grating spaces had been determined. It seemed useful to report the first results obtained for sodium chloride, arsenic trioxide (As_4O_6, octahedral form), and silica (α-quartz), as well as the atomic masses deduced for sodium, arsenic and silicon. Further, we can add (1) another result for the atomic mass of silicon from the very precise data obtained at 20° C. by M. E. Straumanis and E. Z. Aka[2] for octahedral silicon, and (2) the value for the atomic mass of calcium calculated from the excellent measurements made on calcite also at 20° C. by J. A. Bearden[3].

In our calculations of 1950, we adopted calcite as reference standard "because in our opinion its density, grating space and structural geometric constant have been determined with greater accuracy than any other crystalline solid". This was qualified by the remark that "Finally, it would be better to take as reference standard instead of calcite another such as diamond. Then, of course, the value used for the Avogadro number would be that deduced from diamond". In view of the recent beautiful work on diamond of M. E. Straumanis and E. Z. Aka[4], it seems that the time has now come for adopting as standard this latter substance instead of calcite.

Actually, using the 'methode asymetrique' (probably the most exact method available at the present time for determining the grating spaces), Straumanis and Aka have succeeded in making highly accurate measurements on three specimens of very pure diamond between 10° and 50° C. From these data the grating space at 23·5° C. (all corrections made) $d^{23\cdot5} = (3\cdot55961 \pm 0\cdot00001_6)$ A., $d'^{23\cdot5} = (3\cdot56682 \pm 0\cdot00006_8) \times 10^{-8}$ cm., taking into account that to convert to absolute values the values expressed in the Siegbahn scale, multiplication by the factor $(1\cdot00202_8 \pm 0\cdot000015)$ is necessary. The temperature of 23·5° C. is that at which J. A. Bearden[5] determined the density of diamond which seemed then to be the most probable value, namely, $\rho^{23\cdot5}_{\text{diamond}}$ $(3\cdot51836 \pm 0\cdot00004)$ gm./cm.^{3}.

In our opinion, the diamond is much better than calcite as a reference standard because the uncertainty in the molecular weight of the latter is much greater than that of the atomic weight of carbon. As already stated, in taking diamond as the reference standard the value for the Avogadro number used in the calculations must necessarily be that referred to diamond. Now the unit cell of the latter contains eight atoms of carbon and the formula to be used will be:

$$8\,M_{\text{diam.}} = N_A \cdot \rho_{\text{diam.}} \cdot (d'_{\text{diam.}})^3, \qquad (1)$$

in which the symbols $\rho_{\text{diam.}}$ and $d'_{\text{diam.}}$ represent in our case the density and the grating space of diamond at 23·5° C. For the atomic weight of carbon we assume $C = (12\cdot011 \pm 0\cdot0005)$ in agreement with that recently found in this laboratory[6] by means of the gas dimethyl ether $(CH_3)_2O$, namely, $C = (12\cdot011_8 \pm 0\cdot001_7)$ and identical with the value now considered as most probable by E. Wichers[7]. On substituting the appropriate data in formula (1), the value of the Avogadro number is found to be:

$$N_A = (6\cdot0236 \pm 0\cdot0006_8) \times 10^{23},$$

a result used in all the calculations of atomic masses in question here.

Sodium chloride. The pyknometric measurements made by M. Carreira at 18° C. in this laboratory, using our precision technique (slightly modified), on very pure sodium chloride—fused and carefully dried beforehand—gave for the density $\rho^{18}_{NaCl} = (2{\cdot}16383 \pm 0{\cdot}00005)$ gm./cm.³. By taking for the grating space the value determined at 18° C. by Y. Tu[6], namely, $d'^{18}_{NaCl} = (5{\cdot}63978 \pm 0{\cdot}00003) \times 10^{-8}$ cm., and since the unit cell of sodium chloride contains four pairs of ions, the formula is

$$4\,M_{NaCl} = N_A\,\rho_{NaCl} \cdot (d'_{NaCl})^3, \qquad (2)$$

from which $M_{NaCl} = (58{\cdot}453 \pm 0{\cdot}008_8)$ and on subtraction of Cl = 35·457, the atomic weight of sodium is $22{\cdot}996 \pm 0{\cdot}008_8$.

Arsenic trioxide (octahedral). Starting with As_4O_6 (Merck) and after very great care in purification, M. Carreira has obtained several measurements the mean of which gives for the density at 23° C. the value $\rho^{23} = (3{\cdot}8685 \pm 0{\cdot}0001_4)$ gm./cm.³. By taking for the grating space the value determined, also at 23° C., by Straumanis and Ievins[5], namely, $d' = (11{\cdot}0745 \pm 0{\cdot}0001) \times 10^{-8}$ cm., and applying the formula:

$$8\,M_{As_4O_6} = N_A\,\rho_{As_4O_6} \cdot (d'_{As_4O_6})^3, \qquad (3)$$

one gets for the molecular weight of As_4O_6 $(395{\cdot}621 \pm 0{\cdot}061)$ and for the atomic weight of arsenic:

$$As = (74{\cdot}905 \pm 0{\cdot}015).$$

Silica (α-quartz). Using pure transparent quartz from de Noya (La Coruna, Spain), M. Carreira has made pyknometric measurements at 18° C. by means of the same refined technique. The general means of the measurements give for the density of silica (α-quartz) the value $\rho^{18}_{SiO_2} = (2{\cdot}64875 \pm 0{\cdot}00008)$ gm./cm.³. For the grating space we accept the values found by A. H. Jay[10] at 18° C., namely, $a = 4{\cdot}9029$ A. and $c = 5{\cdot}3933$ A., which in absolute measure are $a' = 4{\cdot}9128_5 \times 10^{-8}$ cm. and $c' = 5{\cdot}4042 \times 10^{-8}$ cm. Assuming the unit cell of quartz, of hexagonal structure, consists of nine molecules of SiO_2, the formula becomes:

$$9\,M_{SiO_2} = 3.\sqrt{\frac{3}{2}}\,N_A \cdot \rho_{SiO_2} \cdot a'_{SiO_2} \cdot c'_{SiO_2}, \qquad (4)$$

from which the atomic weight of silicon is

$$Si = 28{\cdot}076.$$

The probable errors in M_{SiO_2} and Si are not given because the uncertainty in the values of the grating space a and c measured by A. H. Jay are not known.

Silicon (octahedral). The measurements recently carried out on pure crystallized silicon by M. E. Straumanis and E. Z. Aka[3] have fixed with high accuracy the density and grating space of this element. The values found are $\rho^{20}_{Si} = (2{\cdot}3283_1 \pm 0{\cdot}00031)$ gm./cm.³ and $d^{20}_{Si} = (5{\cdot}41991 \pm 0{\cdot}00003)$ A., which on the absolute scale is $d'^{20}_{Si} = (5{\cdot}43089 \pm 0{\cdot}00011) \times 10^{-8}$ cm. Since the unit cell of silicon (octahedral) contains eight atoms, the formula is

$$8\,M_{Si} = N_A\,\rho_{Si}\,(d'_{Si})^3, \qquad (5)$$

from which the atomic weight of silicon is

$$Si = 28{\cdot}081 \pm 0{\cdot}0073.$$

In view of the calculated probable error, this figure may be regarded as in agreement with the value obtained from silica.

Calcite. The measurements on pure calcite made by Bearden and by Bearden and Shaw[3] allow the values at 20° C. of density, grating space and geometrical structural constant to be calculated to a very high degree of accuracy. The values are $\rho^{20} = (2{\cdot}71030 \pm 0{\cdot}00003)$ gm./cm.³, $d'^{20} = (3{\cdot}03567 \pm 0{\cdot}00005) \times 10^{-8}$ cm. and $\varphi(\beta) = (1{\cdot}09594 \pm 0{\cdot}00001)$. Since the unit cell of calcite contains four pairs of ions, the formula for the calculation of molecular weight is:

$$4\,M_{CaCO_3} = N_A \cdot \rho_{CaCO_3}\,\varphi(\beta) \cdot (d'_{CaCO_3})^3, \qquad (6)$$

from which $M_{CaCO_3} = (100{\cdot}105 \pm 0{\cdot}017_8)$, and subtracting $CO_3 = 60{\cdot}011 \pm 0{\cdot}0005$, the following figure is obtained for the atomic weight of calcium:

$$Ca = (40{\cdot}094 \pm 0{\cdot}017).$$

These results, in our opinion, show clearly that the pykno–X-ray method, in its new form, must now be ranked as one of the methods of precision for the determination of the atomic masses of the chemical elements. It is true that the possible errors in the method can sometimes become fairly large, as is the case with calcium. At the same time, it may be emphasized that this would only be the case if, in absence of all compensation, the errors were all in the same direction and hence cumulative. Usually at least a partial compensation takes place, so that in general the errors affecting the results furnished by the pykno–X-ray method will be rather small.

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INCORPORATION OF 8-AZAGUANINE INTO NUCLEIC ACIDS

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8-AZAGUANINE, which differs from guanine in having the carbon atom at position 8 replaced by nitrogen, inhibits the growth of certain bacteria, fungi, algae, protozoa, animal tumours, and some plant and animal viruses. Some evidence has been presented[1] that, in certain of these cases, 8-azaguanine

can be recovered from acid hydrolysates of the ribonucleic acids, and in one instance[3] there is indirect evidence for the presence of the compound in a nucleotide fraction. The isolation of a compound only as the free base from nucleic acids is not conclusive evidence of its incorporation, for we have frequently observed that ribonucleic acid preparations from tissues treated with 8-azaguanine, and even from viruses isolated from treated host plants, may be contaminated with small amounts of free 8-azaguanine. Only in the case of tobacco mosaic virus[3] has it been conclusively shown, by isolation of material with the expected properties of 8-azaguanylic acid, that 8-azaguanine is incorporated into the nucleic acid.

We have now isolated a compound with the properties of 8-azaguanylic acid from alkaline hydrolysates of ribonucleic acids from the following after treatment with 8-azaguanine : *Bacterium coli*, *Staphylococcus aureus*, mouse liver and spleen and mouse sarcoma *S* 37 (in both the solid subcutaneous and the free-growing ascites forms).

B. coli strain '*B*' was grown on a synthetic medium[4] and two purine-less mutants of *B. coli* were grown on the same medium supplemented with minimal amounts of guanine. *Staph. aureus* was cultivated on a synthetic medium supplemented with small amounts of 'Marmite'. 8-Azaguanine was added to the media in concentrations between 100 and 150 μgm./ml. The bacteria were washed in 0·14 *M* sodium chloride, defatted and dried. Ribonucleic acid was extracted in *M* sodium chloride at 100°, deproteinized, and hydrolysed in *N* potassium hydroxide for 18 hr. at 37°.

Mice inoculated subcutaneously with sarcoma *S* 37 were injected intraperitoneally with two daily doses of 85 mgm. 8-azaguanine/kgm. body-weight, commencing five days after inoculation and continuing for five to seven days. Mice inoculated with sarcoma *S* 37 in the ascites form (where the cells grow freely suspended in the abdominal cavity) were similarly treated. Twenty-four hours after the last injection, the animals were killed, and the tumours, livers and spleens collected. In each case, livers, spleens and tumours were also taken from untreated tumour-bearing mice. 'Ribonucleoprotein' and 'deoxyribonucleoprotein' fractions were extracted from the tissues[5]. Ribonucleic acid was prepared by extraction of the 'ribonucleoprotein' fraction with *M* sodium chloride at 100°, partially purified and hydrolysed in *N* potassium hydroxide.

The methods used for the separation and identification of 8-azaguanylic acid have already been described[3]. 8-Azaguanylic acid isolated from alkaline hydrolysates of ribonucleic acid by paper electrophoresis at *p*H 9 was further characterized : (1) by chromatography in the ammonium sulphate – water solvent which separates the material into two spots corresponding to 8-azaguanosine 2′ and 3′ phosphates ; (2) by hydrolysis in *N* hydrochloric acid at 100° to give a product with the chromatographic properties of 8-azaguanine ; (3) by the ultra-violet absorption spectra of 8-azaguanosine 2′ and 3′ phosphates and the base obtained from them after acid hydrolysis. The ribonucleic acid obtained from 8-azaguanine-treated *B. coli* hydrolysed with snake venom diesterase and 5′-nucleotidase contained a substance with the expected properties of the nucleoside, 8-azaguanosine.

Table 1 gives the approximate amounts of 8-azaguanylic acid found in the various ribonucleic acids.

Table 1. Approximate 8-Azaguanylic Acid Contents of Ribonucleic Acids from Organisms treated with 8-Azaguanine

Source of ribonucleic acid	Moles 8-azaguanylic acid/100 moles ribonucleotides
Bacterium coli	0·2–0·5
Staphylococcus aureus	> 0·5
Mice bearing subcutaneous tumour (*S* 37)	
spleen	0·15–0·2
liver	0·2–0·4
tumour	0·05–0·1
Mice bearing ascites tumour (*S* 37)	
liver	none detected
tumour	0·15–0·2

With the purine-requiring mutants of *B. coli*, increasing the amount of guanine in the medium considerably decreased the incorporation of 8-azaguanine. We have confirmed that 8-azaguanine inhibits the growth of *B. coli*.

Although a substantial amount of 8-azaguanylic acid was isolated from the liver ribonucleic acid from animals bearing subcutaneous tumours, none could be detected in liver ribonucleic acid from animals with ascites tumours (Table 1). Possibly the flow of lymph into the abdominal cavity which accompanies the development of the ascites tumours restricts the absorption of 8-azaguanine into the general circulation. The higher 8-azaguanine content of ribonucleic acid from ascites tumour cells compared with that from subcutaneous tumour cells is presumably due to the ascites tumour cells being in direct contact with much higher concentrations of the compound.

Treatment of animals bearing the subcutaneous form of the *S* 37 sarcoma with 8-azaguanine resulted in a delay of tumour growth, particularly during the first days of treatment. Livers and spleens from the treated animals showed no macroscopic changes, and histological examination revealed no signs of degeneration.

Tumours developed in all five control animals inoculated with the ascites form of *S* 37, but only in four out of the seven animals treated with 8-azaguanine. In these the mitotic rate of the tumour cells was reduced and the final volume of tumour cells per animal was about 40 per cent that of the controls.

Evidence has been given that particles of tobacco mosaic virus containing 8-azaguanine incorporated into their ribonucleic acid are non-infectious[6], so it seems likely that the growth inhibition in bacteria and animal tissues may be largely due to the synthesis of biologically inactive ribonucleic acid containing 8-azaguanine. The results of Carlo and Mandel[7] would not be inconsistent with this view. They found that 8-azaguanine had no significant effect on the incorporation of carbon-14 labelled guanine or 4-amino-5-imidazolecarboxamide into the nucleic acids of liver or sarcoma *S* 37 of mice. Any compound such as the riboside or nucleotide of 8-azaguanine which might be incorporated more readily than 8-azaguanine itself into ribonucleic acids will be of interest, particularly in systems such as tumours and viruses where growth inhibition is a desirable end.

We have attempted to detect 8-azaguanine in the deoxyribonucleic acid of liver, spleen and the tumours from mice treated with 8-azaguanine, and in that of *B. coli* '*B*' and its bacteriophage T_2r^+ grown in the presence of 8-azaguanine. The purines were liberated from deoxyribonucleic acid by hydrolysis in *N* hydrochloric acid at 50° and separated by chromatographic and paper electrophoretic techniques which would

have allowed the easy detection of 8-azaguanine. In no case was this observed.

While we cannot exclude the possibility that the 8-azaguanine may be incorporated into deoxyribonucleic acid in amounts too small to be detected by our methods, there are structural considerations which may make its incorporation unlikely. In the Watson and Crick[8] model of deoxyribonucleic acid, the keto form of the 6(OH) group of guanine forms an essential part of the hydrogen-bonded structure. The *p*K of the 6(OH) group in 8-azaguanine is 2–3 *p*H units below that of guanine[9], so that at physiological *p*H values the percentage of molecules not in the keto form would be considerable. [Dec. 10.

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ESTIMATION OF ZINC IN BIOLOGICAL SPECIMENS

Determination of Zinc-65

THERE is evidence that zinc is necessary for animals and plants; but information about the physiological role of this metal is scant. The enzyme carbonic anhydrase, present in red blood cells and certain other tissues, contains zinc as an integral part of the protein molecule[1]; but little is known about the way in which zinc is combined in other animal tissues. In recent years considerable interest has been shown in the distribution of this metal in various tissues. It has been shown, for example, that human leucocytes contain two zinc-containing protein complexes[2], that some of the zinc in tumour tissue is loosely bound to nucleoprotein in the cell nuclei[3], and that zinc in egg yolk is firmly bound to the protein part (vitellin) of lipovitellin[4].

The use of a radioactive isotope of zinc (^{65}Zn) has greatly facilitated recent studies on zinc metabolism, and when radioactive zinc of high specific activity becomes more generally available, it is expected that there will be an increasing need for comparatively simple methods for measuring the amount of zinc-65 in tissues. In our own investigations we are using three different methods, and the following brief outline of these methods may be helpful to others who contemplate using it for biological investigations. A more complete account will be given elsewhere.

(1) *Quick, wet combustion method.* This method, a simplified version of method (2), involves the heating of a weighed amount of the tissue (for example, 0·1–5 gm.) with concentrated nitric acid or concentrated sulphuric acid (2 ml. per gm., with a minimum of 1 ml.) until a clear solution is obtained. When sulphuric acid is used, selenium dioxide (about 5 mgm. per ml.) should be added as a catalyst, and the digest can then be used for a total nitrogen determination. (Sulphuric acid has a further advantage over nitric acid in this respect, for acid fumes from the diluted nitric acid digest may cause corrosion of the counting equipment.) The acid digest is diluted with water to a standard volume (for example, 15 or 20 ml.) and the radioactivity of 10 ml. of this solution is measured in a Veall-type[5] counter for liquids.

We have found that under these conditions no correction for self-absorption is normally required, and the method gives complete recovery of zinc-65 added (as zinc chloride) to animal tissues or present in the tissues of animals previously injected with the isotope.

(2) *Extraction method*[6]. Where there is a possibility that the material to be analysed contains significant amounts of radioactive isotopes other than zinc-65, some method of extracting the zinc from the digested tissue should be adopted. The tissue should be completely digested by long heating with an acid mixture, ammonia added to bring to *p*H 8·5–9·0, and the solution repeatedly shaken with a solution of dithizone in carbon tetrachloride to extract the zinc. The zinc in this zinc–dithizone solution is then extracted by dilute hydrochloric acid, and the radioactivity of this acid solution measured directly in a Veall-type counter.

This method is laborious, and it involves considerable manipulation and transference of solutions, with a loss of 3–5 per cent of the zinc-65.

(3) *Scintillation counter method.* Recently we have been using a scintillation counter for measuring the amount of zinc-65 in tissues, and, as we had expected (mainly from consideration of the decay scheme of zinc-65), this method proved to have several advantages over those which involve the use of a Geiger counter. Since the scintillation counter measurements are entirely concerned with the γ-radiation of this isotope, the preparation of the tissue for the determination is simple. Radioactivity measurements can be made on the homogenized tissue or on the solution obtained by heating the tissue with sulphuric acid as in method (1), and no self-absorption correction is required.

Table 1 gives a few typical results obtained with tissues (mouse liver and mammary gland) to which zinc-65 had been added (as zinc chloride) or which had been removed from mice previously injected with the isotope. In these particular experiments the tissues were first subjected to short acid digestion, to permit comparable determinations to be made with a Geiger counter, and scintillation counter measurements were made on 3–5 ml. of the diluted digest.

The results of these and many similar experiments have shown that for zinc-65 determinations the scintillation counter has a much greater sensitivity and consistency than has the Geiger counter. Furthermore, long acid digestion of the tissue is not required. Recently, we have found the scintillation counter method most helpful for determinations of the zinc-65 content of the fæces of hens which have been injected with the isotope, for direct measurements

Table 1. Comparative Count-rates for Zinc-65 in Animal Tissues when measured with Scintillation Counter (SC) and Geiger-Müller Counter (GC) for Liquids (Type *M6*)

Tissue (No.)	Gross count-rate (counts per min.)		Background count-rate (counts per min.)		Ratio (net count-rate of sample/background count-rate)	
	SC	GC	SC	GC	SC	GC
1	28,200	1,008	309	18	90	55
2	7,800	298	315	15	23·8	18·9
3	1,290	57	322	16	3·0	2·6
4	512	23	315	16	0·6	0·4

can be made on the homogenized fæces. Wherever cross-checks have been made, the results obtained with the scintillation counter have been identical with those obtained with methods (1) and (2) above.

These investigations have been carried out with the aid of grants from the British Empire Cancer Campaign and the Medical Research Council, and we are also indebted to Prof. P. B. Moon and Prof. W. E. Burcham for the arrangements under which we were able to obtain irradiated copper target bars from the Birmingham cyclotron. The activated sodium iodide crystal used for the scintillation counter was supplied by the Atomic Energy Research Establishment, Harwell, and we are grateful to Dr. Denis Taylor and Mr. R. B. Owen for their help in this matter.

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Separation of Radioactive Zinc from Cyclotron-irradiated Copper

The chemical separation of radioactive zinc of very high specific activity from cyclotron-irradiated copper usually presents considerable practical difficulties on account of the minute amounts of total zinc which have to be separated from relatively large amounts of copper.

In the method described here, the irradiated copper target, which has usually been plated with spectrum-pure copper before irradiation, is arranged as the anode of an electrolytic cell containing 100 ml. of dilute sulphuric acid (about 4 *N*). Any parts of the surface of the target which are not to be brought into solution are protected by a coat of varnish. A copper-foil cathode is used, and a potential difference of 1 volt is applied. Electrolysis is continued until almost all the zinc-65 has been removed from the target, the solution in the cell being changed several times during this process. Each radioactive solution obtained is evaporated to dryness and the residue dissolved in an *n*-butanol–hydrochloric acid mixture (96 volumes of redistilled *n*-butanol to 4 volumes of constant-boiling hydrochloric acid). This solution is transferred to a cellulose-powder chromatography column (Whatman's ashless filter-paper powder), and the metals eluted with the same solvent mixture. Under these conditions, zinc moves rapidly down the column and is completely eluted before the visible green band, due to cupric chloride, approaches the bottom of the column. The radioactive eluates from each electrolysis fraction are pooled and the solvents

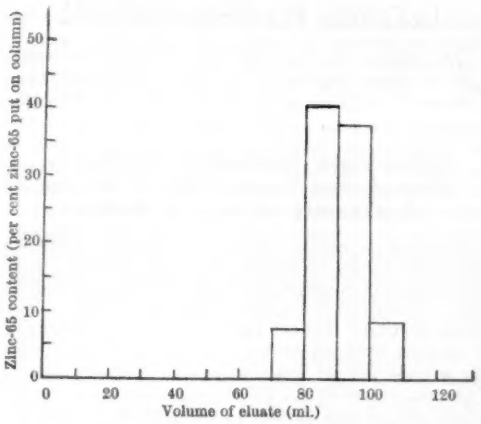

Fig. 1. Chromatographic separation of zinc-65 from irradiated copper (cellulose powder column 10 in. long and 1 in. diameter)

removed by distillation under reduced pressure. The residue is dissolved in a small volume (5–10 ml.) of constant-boiling hydrochloric acid. Copper cannot be detected in this final acid solution by a spot test depending upon the catalytic action of cupric ions on decomposition of the ferric iron – thiosulphate-complex ion[1]. This reaction will detect 0·02 μgm. copper at a minimum concentration of 1 part in 2,500,000. The fractions obtained from the surface of the target do not contain sufficiently large amounts of zinc to be detectable by the formation of zinc mercuric thiocyanate in a spot test[1] (sensitivity: 0·2–0·5 μgm. zinc at a minimum concentration of 1 part in 100,000). The fractions obtained from the deeper parts of the target contain small (microgram) amounts of carrier zinc, which may be derived from non-radioactive zinc originally present as an impurity in this part of the target. It has been shown that, under the conditions of these separations, the cellulose powder and reagents do not contribute detectable amounts of zinc to the product.

An example of the recovery of radioactive zinc in serial 10-ml. fractions of the eluate is shown in Fig. 1. The relatively large volume of the solutions chromatographed has necessitated the use of larger columns than those recommended for the chromatographic separation of metals in analytical work[2]. Good results have been obtained with cellulose columns 10 in. long and 1 in. in diameter, and with columns 14 in. long and 1½ in. in diameter.

We are indebted to Prof. A. Wormall for his interest and encouragement, and to the British Empire Cancer Campaign for financial support. The irradiations were performed in the University of Birmingham cyclotron through the courtesy of Profs. P. B. Moon and W. E. Burcham.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Ultra-Violet Irradiation of Tobacco infected with Potato Virus Y and the Availability of Virus to Aphids

Since many workers in widely divergent fields are interested in the biological effects of ionizing radiations, new methods of approach to this study may have wider application than is at first realized. This communication reports that ultra-violet irradiation of tobacco infected with potato virus *Y* can reduce the availability of virus to aphids without causing apparent injury to the plants or greatly reducing the infectivity of sap extracts as measured by starch – iodine lesions.

Leaves of White Burley (*Nicotiana tabacum* L.) tobacco plants showing well-developed symptoms of infection with potato virus *Y* were irradiated in the dark 15 cm. from a source of ultra-violet light. (The intensity of radiation of 2537 A. on the surface of the leaves was about 2 mW. per sq. cm.) Half of each leaf was either removed or covered during irradiation to serve as an unirradiated control. After irradiation, the plants were placed in daylight under glass for several hours, and then kept under normal glasshouse conditions of illumination. The availability of virus to aphids was tested with fasted wingless adults of *Myzus persicae* (Sulz.), which were transferred in pairs from the source of infection to young healthy tobacco plants for 24 hr.

When aphids spent two minutes on the leaves immediately after irradiation, the pairs out of 70 that transmitted from leaves irradiated zero, two, four and eight minutes were 68, 28, 11 and 1 respectively. Many fewer transmissions resulted when the aphids spent four hours on the leaves; but the differences in the numbers of transmissions from irradiated and unirradiated leaves were similar to those above. Irradiation of one surface of a leaf did not affect the availability of virus from the other; nor did irradiation appear to affect the feeding behaviour of the aphids. The irradiated plants continued to grow and looked the same as the controls, and the availability of virus to aphids returned to normal within a few days. For example, after two to four days, as many transmissions were obtained from leaves irradiated two minutes as from the controls, and transmissions from leaves irradiated five minutes equalled that of the controls after five to ten days.

Ultra-violet irradiation of some plant viruses *in vitro* results in a loss of infectivity without any gross changes in their physiochemical properties[1] and, by analogy, virus infectivity is probably destroyed *in vivo* when infected plants are irradiated. Although detailed infectivity tests have not yet been done, the following tests indicate that if ultra-violet destroys infectivity *in vivo*, then only a small part of the total virus in a leaf is so affected during the brief periods of irradiation required nearly completely to reduce the availability of virus to *M. persicae*. Infected leaves were divided along the mid-veins, and one-half of each leaf was irradiated for five minutes, the other half serving as an untreated control. The pairs of aphids out of 20 that transmitted virus after two minutes on these leaves were zero for the irradiated and 18 for the controls. Sap expressed from each group of half-leaves and diluted with an equal volume of phosphate buffer at *p*H 7 was inoculated on opposite half-leaves of tobacco. Sap from the irradiated leaves produced as many starch – iodine lesions[2] as that from the controls in one experiment; when repeated, however, slightly fewer lesions were produced by sap from the irradiated leaves, the difference being less than 10 per cent.

M. persicae becomes infective with potato virus *Y* during feeding punctures when the stylets are inserted into the epidermis of infected plants, and transmission rarely, if ever, occurs after the stylets have penetrated into deeper tissues[3]. Therefore, it is only necessary to postulate inactivation of potato virus *Y* in the epidermis of the irradiated tobacco leaves to account for the results reported here.

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Protein Synthesis and Genetics

The recent exchange of views in *Nature* regarding the biosynthesis of proteins prompts some comments from a geneticist. Campbell and Work[1] take note of "the two main streams of thought on protein synthesis: one derived from the study of isolated enzyme systems and suggesting a stepwise coupling of many small peptide units; the other based on the study of genetic inheritance of protein specificity and preferring synthesis on templates, each template being specific for a single protein structure and probably identifiable with a gene". While not rejecting the latter view (one gene – one protein), they point to some of the difficulties with which it is confronted, and further suggest the possibility that a synthesis of the two ideas will be found to fit the facts. Dounce[2], on the other hand, elaborates and defends a nucleic acid template hypothesis, and suggests that such a hypothesis is consistent with the existence of both plasma genes and nuclear genes. Quite independently, immunogenetic and biochemical studies of controllable genetic material have yielded results suggesting a synthesis of these views.

In *Drosophila melanogaster*, genic interaction has been demonstrated in the determination of antigenic specificity, a finding difficult to reconcile with the one gene – one protein hypothesis. In one series of isogenic stocks, interaction between at least three non-allelic loci is responsible for the presence or absence of a particular antigenic component. Two of these loci have been identified (ruby and vermilion), and have morphological as well as antigenic effects[3]. In another series of isogenic stocks, interaction between alleles results in a distinctive antigenic component in heterozygotes. The interaction involves the wild and mutant alleles at the loci

for lozenge *BS* and/or lozenge-46 [4], which are also notable for their pseudoallelism[5]. In the former case the interaction antigen is undoubtedly protein[6], and in the latter case it is probably protein. The patterns of interaction in these cases are such as to suggest that protein synthesis occurs in two gene-controlled stages: a series of preliminary steps leading to the production of non-specific precursors, and a second stage during which final specificity is conferred upon the product.

In *Neurospora crassa*, the genetic control of the enzyme tyrosinase in strain 15300 (albino-2) has been subjected to intensive investigation. Only a preliminary report has been published[7] and the analysis is not yet complete, but available results are suggestive enough to deserve comment. The enzymatic activity of homogenates of cultures grown under standardized conditions has been measured with two substrates, tyrosine and 3,4-dihydroxyphenylalanine. As has been reported, the two mating types of strain 15300 differ in tyrosinase activity, mating type *a* exhibiting high activity and *A* exhibiting no measurable activity. Single ascospore cultures isolated from the crosses 15300*A* × 15300*a* also exhibit differences in tyrosinase activity, ranging from activities as low as that of 15300*A* to activities higher than that of 15300*a*, and varying independently of mating type. The distribution of activities among cultures of the progeny suggests multiple factorial inheritance. Since the differences in activity cannot be attributed to extraneous factors such as inhibition, the simplest interpretation of these results is that the level of enzyme concentration in this strain is controlled by a multiple genic system. Completion of the genetic analysis of this situation has awaited the development of suitable genetic methods[8], and is now under way.

The specificity of the enzyme, as measured in terms of its relative activity with the two substrates, also varies among the cultures, but independently of level of activity. The inheritance of this difference is again not simple; but the data suggest one locus with a major effect on specificity and several with smaller effects. This situation is also being investigated further.

Tentative as they are, these results nevertheless suggest a duality in the genetic control of tyrosinase synthesis. One genetic system seems to control enzyme concentration, and a second seems to control enzyme specificity. Such duality suggests in turn a two-stage process in enzyme synthesis: a preliminary stage involving the synthesis of non-specific precursor (protyrosinase) under the control of one genetic system, and the conversion of precursor to enzyme (tyrosinase) under the control of a second system. Quantitative aspects of enzyme synthesis could involve the first stage, and specificity could be conferred during the second. This hypothesis has led to the demonstration of protyrosinase in this material. The kinetics of its development and the mechanism of its conversion to active enzyme are being studied.

The similarity of the conclusions drawn from the two aspects of this work, that with *Drosophila* and that with *Neurospora*, is notable. In connexion with the previous discussion in *Nature*, it might be suggested that the synthesis of non-specific precursor occurs in a stepwise fashion, while specificity is the function of template action. If this is the case, the gene – template relationship cannot be simple, as judged from our *Neurospora* data, and perhaps the template itself is synthesized by a similar two-stage process. The genetic control of protein synthesis would in any event be indirect and complex, perhaps approaching the level of complexity of the genetic control of morphogenesis.

Such an epigenetic point of view leads one to expect environmental–cytoplasmic–nuclear interactions in protein synthesis, and it is therefore interesting to note that the *Neurospora* tyrosinase appears to be adaptive. The genetic analysis is therefore performed with material grown in the presence of substrate (tyrosine); but the observation of enzyme adaptation suggests a cytoplasmic mechanism which is triggered by environmental factors and which interacts with the nucleus, such as has been discussed by other workers[9].

I wish to acknowledge the contributions made to this work by Mr. V. Feldmiller, Mr. R. O. Wolf, Dr. A. Chovnick and Dr. S. Koritz. The work itself was supported by research grants from the National Institutes of Health and performed at the Ohio State University.

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Culture *in vitro* of Cambial Tissue of Cacao

DURING work on the physiology of rooting cacao cuttings, attempts were made to induce the formation of roots on isolated stem sections in sterile culture. Although no differentiation was obtained, the profuse growth of callus tissue at the morphological base of the section suggested that cacao would be a suitable subject for tissue-culture investigations.

Further experiments showed that isolates of bark similar to bud 'shields' could be cultured successfully on a simple solid medium, such as that used by Gautheret[1] for his initial isolations. These cultures produced sufficient cambial tissue in two to three months for subcultures to be made; growth of the new tissue was visible after 24 hr. No external source of growth substance was found to be necessary for growth.

The nutritional requirements of the sub-cultures, consisting of cambial tissue only, were more complex than those of the original isolates. White's standard formula[2] supported only very slow growth. Spectacular increases in the growth-rates were obtained, however, with the addition of coconut milk in varying concentrations to White's medium. The highest rate of growth was given on a medium of pure coconut milk. The subcultures were grown on liquid medium by a method similar to that described by Stokes[3] for

embryo-culture. Initial isolates did not grow as well using the liquid method of culture as on a solid medium.

No external source of growth substance was employed with those media containing coconut milk. Subcultures grown on White's medium alone showed no response to the addition of low concentrations of growth substance, and higher concentrations, of the order of 10^{-5}, caused considerable losses.

Isolates from plants infected with 'swollen shoot' virus have also been cultured successfully. Eight to ten successive subcultures have been made from isolates from such infected plants. It has not yet been possible to demonstrate the presence of the virus in the isolates or in the newly formed tissues. This may be largely because of the limitations imposed by the available methods of testing for the virus. The nutritional requirements of the 'infected' cultures are similar to those of healthy tissues, and the growth-rates are similar. Histological examination of these tissues has so far shown no differences from healthy tissues.

Referring particularly to the tissue of *Vitis*, Gautheret[1] suggests that the physiology of this tissue is so greatly changed, when cultured upon a medium containing coconut milk, as to bear no relation to that of normal tissue, and that the intense proliferation of the tissue is often of a pathological nature.

The tissue produced upon explants from cacao is normally compact, white and granular. When subcultured upon White's standard medium with pantothenic acid and biotin, the newly formed tissues present a similar appearance. No growth takes place at the point of contact of the culture with the medium, whether the latter be liquid or solid. When subcultured upon a medium containing coconut milk, however, the morphology of the tissue is greatly changed. Further, there is a considerable difference between tissues cultured on solid media and those on liquid.

On agar slopes, the typical white mass of tissue is gradually overgrown by a disorganized, loosely granular tissue, which is pale brown in colour and translucent. The growth is rapid compared with that on the standard medium. The subcultures retain this appearance. When subcultured on liquid coconut milk by Stokes's[3] method, the change in the morphology of the tissue is even more marked. Proliferation takes place only at those points of the culture in contact with the medium-soaked filter paper. The original tissue is raised from the surface of the paper by one or more masses of new tissue. The latter, while still pale brown and translucent, is compact but extremely soft and 'mushy'. The original culture ultimately dies. Further subculture of the new tissue is made easy by the fact that all the cells composing it seem capable of division; it is so soft that a smear of the tissue across the surface of the filter paper support will, in the course of a month, give rise to masses of tissue large enough for further subculture.

After about four subcultures on coconut milk, in some cases a further change in the morphology of the cultures is noticeable. The tissue becomes practically colourless, and of a much more granular and solid nature. This form is maintained in succeeding subcultures. The differences in morphology of those cultures grown on agar slopes containing coconut milk, compared with those grown on a liquid medium, are probably due to the greater availability of nutrients, growth substances and the so-called 'coconut milk factor' in the latter.

I wish to thank the Director of Cacao Research, West African Cacao Research Institute, for permission to publish this communication. A full report of the work will be given later.

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Occurrence of Endosperm Haustoria in some Cucurbitaceae

The embryology and seed structure of the Cucurbitaceae have attracted much attention, and a good deal of work has been done by Longo, Kirkwood, Kratzer, Singh, and others[1], most of it based on a study of sections. However, sections often fail to give a three-dimensional picture of an organ, and occasionally even simple structures are ignored or overlooked. In my work I used both sections and dissections, and observed characteristic endosperm haustoria in several members of this family, which have not been reported earlier.

Species of the following genera were investigated: *Trichosanthes, Lagenaria, Luffa, Momordica, Cucumis, Citrullus, Coccinia, Cucurbita, Melothria, Blastania* and *Actinostemma*. All these except *Blastania* were found to possess a chalazal endosperm cæcum. A comparative account of the endosperm of *Momordica, Trichosanthes, Luffa* and *Lagenaria* is presented below.

The endosperm is of the nuclear type. Soon after fertilization, the embryo-sac elongates (Fig. 1) and its upper part broadens while the lower remains narrow. Wall formation occurs only in the former. It is simultaneous in *Lagenaria, Luffa* and *Trichosanthes*, whereas in *Momordica* it progresses from the apex downwards (Figs. 2, 3, 4). The chalazal end, which is cœnocytic, forms a tubular process (Figs. 4, 10) which soon becomes worm-like in *Trichosanthes* (Fig. 6) and assumes a shape similar to that of the 'vermiform appendage' of some members of the Proteaceae[2]. Frequently, the nuclei present in the chalazal process are larger than those in the upper cellular part (Figs. 4, 11).

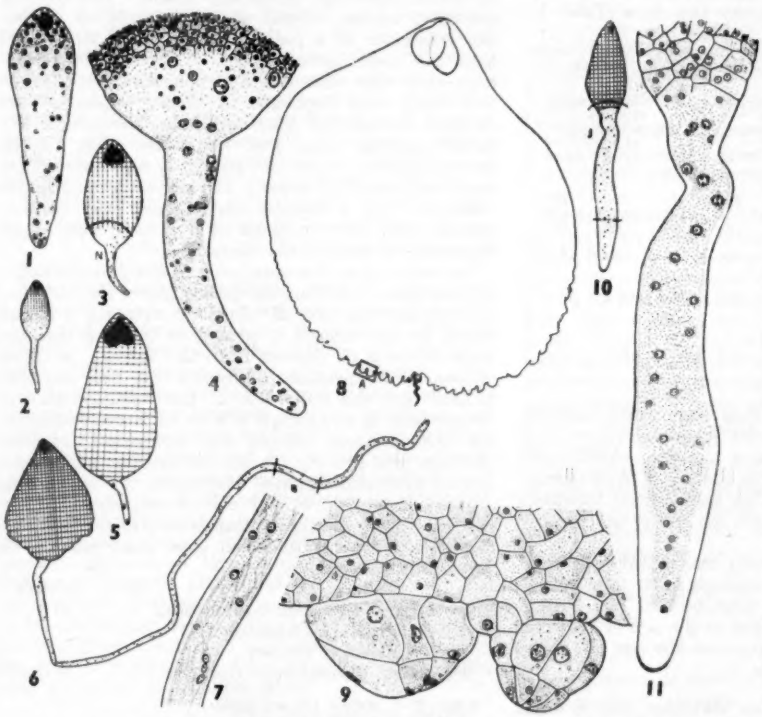
The maximum length attained by the appendage varies from 700 μ in *Momordica* to more than 6,000 μ in *Trichosanthes*. The haustorium shows dense granular cytoplasm with many free nuclei (Figs. 4, 7, 11) which often aggregate in groups of 3–7. The nucellar cells around the appendage present a famished appearance and gradually their walls break down.

The cellular part of the endosperm increases greatly in size by cell divisions and cell enlargement. The nuclei of the centrally situated cells become markedly hypertrophied and irregular in outline. In the basal portion the outer cells bulge out prominently, this feature being specially pronounced in *Luffa* (Figs. 8, 9).

Due to the enormous increase in size of the cellular part of the endosperm and the aggressiveness of the haustorium, the surrounding nucellar tissue is gradually used up.

The chalazal haustorium remains cœnocytic in *Trichosanthes*, *Luffa* and *Lagenaria*. Only in *Momordica* does it sometimes become cellular. It is at the peak of its activity at the heart-shaped stage of the pro-embryo, after which its contents begin to degenerate and disappear and the wall shrinks, and it comes to lie close to the base of the cellular endosperm (Fig. 8).

In advanced stages the endosperm is consumed by the developing embryo, and at maturity the cotyledons occupy the whole of the seed cavity.



Figs. 1–4. Development of endosperm in *Momordica charantia*; for explanation, see text. Fig. 4 is enlargement of the part marked *N* in Fig. 3. Magnification: Figs. 1 and 4, × 75; Figs. 2, 3 and 5, × 16

Figs. 6 and 7. Endosperm of *Trichosanthes anguina*; Fig. 7 is enlargement of the part marked *B* in Fig. 6. Magnification: Fig. 6, × 24; Fig. 7, × 110

Figs. 8 and 9. Endosperm of *Luffa aegyptiaca*; Fig. 9 is enlargement of the part marked *A* in Fig. 8. Magnification: Fig. 8, × 11; Fig. 9, × 112

Figs. 10 and 11. Endosperm of *Lagenaria vulgaris*; Fig. 11 is enlargement of the part marked *J* in Fig. 10. Magnification: Fig. 10, × 9; Fig. 11, × 112

None of the families believed to be allied to the Cucurbitaceae is known to possess a similar endosperm cæcum, but it would be interesting to reinvestigate them using whole mounts as well as sections.

I thank Prof. P. Maheshwari and Dr. B. M. Johri for their encouragement and valuable suggestions during the course of this study.

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Plasmodium berghei in the Placenta of Mice and Rats: Transmission of Specific Immunity from Mother Rats to Litters

The problem of transplacental transmission of *Plasmodium berghei* from mother mice and rats to their litter was investigated by infecting gravid animals during the week preceding parturition. 22 white mice and 12 albino rats were inoculated intravenously with a standard dose of 10^6 parasites per 100 gm. weight of the animal. All mice died within an average of 12·4 days after the infection. Ten rats survived the infection and developed a consequent immunity. 15 mother mice lived long enough to deliver; two of which produced stillborn litters while 13 delivered normally. All live-born baby mice were free from infection at the time of birth, and when nursed by foster mothers remained healthy and developed normally for more than two months. The stillborn mice showed no parasites on direct smears, and sub-inoculations from them were negative; but they had an accumulation of pigment in the liver. This pigment (giving a negative histochemical test for iron) might have been produced as a result of a fatal intra-uterine infection.

Ten gravid rats infected with *P. berghei* showed a typical course of infection followed by recovery. They produced a total of 76 non-infected baby rats, all of which, nursed by their own mothers, developed normally for more than three months. Sections of placentæ of three mother rats showed a heavy concentration of pigmented parasites in decidual sinuses and in the meshes of the placental labyrinth; but the fœtal villi were free from parasites. Neither the syncytial trophoblastic tissue nor the cellular elements of the placental labyrinth showed any marked reaction to parasites accumulated in the lacunæ in very great numbers. The phagocytic activity of the 'giant cells' was not unduly marked, though some of them contained grains of pigment.

It seems that the penetration of parasites through the hæmoendothelial barrier of the placenta of mice and rats is an exceptional occurrence, due perhaps to a mechanical or most probably functional deficiency, and followed as a rule by an early death of the fœtus.

The transmission of specific immunity from mothers to their litter was investigated in rats. Ten adult females were given, after their recovery from

the first infection, three to four weekly intraperitoneal inoculations of *P. berghei*, beginning with 20 million and ending with 60 million parasites. The rats were mated, and during the second half of their pregnancy received one or two intravenous inoculations of 25 million parasites.

All these rats produced normal litters which were nursed by their own mothers. Each litter was divided into three groups, and the combined litters in each group were challenged by an intraperitoneal inoculation of 1–3 million parasites at 2 weeks, 3 weeks and 4–5 weeks of age. The baby rats were followed up by blood examinations every two days (Table 1).

Table 1. Results of Challenging Infections with *P. berghei* of Litters produced by Immune and Normal Mother Rats

	Litter from immune mothers Age at challenge (days)			Litter from normal mothers Age at challenge (days)		
	13–15	20–22	28–32	13–15	21–23	28–34
Numbers challenged	22	20	18	18	19	20
Dose of parasites	10^6	2×10^6	3×10^6	10^6	2×10^6	3×10^6
Numbers died	22	17	9	18	19	19
Mortality (per cent)	100	85	50	100	100	94·5
Average survival time of fatal infections (days)	12·5	15	18·6	10·8	14·6	14·8
Mean peak parasitæmia (per cent parasitized red blood cells)	94·0	80·5	67·4	94·4	98·5	91·0

It appears that young rats born from mothers immune to *P. berghei* exhibit some tolerance to a challenging infection with this parasite, whereas the infection in control baby rats delivered from normal mothers is usually fatal. This transmitted tolerance becomes obvious only towards the end of the nursing period.

To find whether the young rats obtain their inherited relative immunity through milk, four groups of litters produced by two immune and two normal mother rats were interchanged at the age of 3–4 days after birth and later challenged at the age of 15 and 30 days respectively (Table 2).

Table 2. Results of Challenging Infections with *P. berghei* in Two Groups of Interchanged Litters

	Litter from immune mother nursed by a normal mother Age at challenge (days)		Litter from a normal mother nursed by an immune mother Age at challenge (days)	
	15–16	30–32	14–16	31–32
Numbers challenged	6	7	7	8
Numbers died	6	6	6	5
Mortality (per cent)	100	85	85	62·5
Average survival time of fatal infections (days)	14·5	16	12·2	13·5
Mean peak of parasitæmia	91·0	94·6	93·7	76·0

The results of this preliminary investigation suggest that any inherited relative immunity to challenging infections with *P. berghei* in young rats is transmitted mainly by milk of immune mothers and evident only during the late part of the nursing period.

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Spawning Sites of Trout

In a previous communication[1], it was stated that field observations suggest there is a regular downward flow of water through the gravel beneath the river-bed at the sites favoured by salmon and trout when making the spawning redd. The course of these sub-surface currents, as experimentally determined in the laboratory in a 6 ft. × 1 ft. artificial stream pool, was described. It was found that the maximum flow occurs in the vicinity of the mound of gravel usually present near the lower end of a spawning pool, that is, where redds are commonly found. The present spawning season offered an opportunity of testing the behaviour of a pair of gravid trout introduced into the experimental pool. Normal 'courtship' behaviour was observed and spawning took place. Ova (425) were deposited in three pockets, all excavated within the predicted area, the site of the initial cutting being just below the apex of the gravel mound, where the strongest sub-surface flow had been found to occur; 100 per cent fertilization resulted. In a second experiment with another gravid pair, three pockets of ova have been again deposited in exactly the same site.

An interesting demonstration of the penetration of stream water into the sub-surface gravel was obtained by burying ripe ova, obtained by stripping a female trout, in the mound of gravel in the experimental tank, some 4 ft. distant from the inflow. A dilute suspension of spermatozoa from a ripe male was then poured into the inflow rush. Investigation showed 30 per cent of the buried ova to have been fertilized by spermatozoa carried by downward currents through the gravel. A second similar experiment with a more concentrated suspension of spermatozoa yielded just over 60 per cent fertilization. These results suggest that in a stream with a mixed salmonid population cross-fertilization is at least possible on physical grounds.

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A New Species of Freshwater Triclad belonging to the Genus *Polycelis*

Our studies of the genus *Polycelis* from western Europe have revealed that the species complex *nigra-tenuis* in reality includes not two but three different species, which are easily recognized if the anatomy of the copulatory organs or the chromosomes are studied. However, it is scarcely possible to identify these species from their external appearance.

Below, the main species differences are set down, though the anatomy (E. H.-M.) and the chromosomal conditions (Y. M.) will be described soon, in full, elsewhere.

Polycelis nigra (O. F. Müller, 1773) has a short, rounded penis with two to three rows of chitinous spines around its opening. The glandular bursalis is large. There are no adenodactyls.

Polycelis tenuis Ijima, 1784 has a large, long and pointed penis, the surface of which is covered with thick chitinous spines. The glandular bursalis is a small one. This species always has two well-developed adenodactyls.

Polycelis hepta n.sp. will be the name of the new species formerly confused with the other two. It has a large pointed penis like that of *tenuis*. The distal third of the surface of the penis is covered with small epithelial light-refracting bodies. The glandular bursalis is similar to that of *tenuis*. There are never any adenodactyls in *hepta*.

The haploid chromosome number is 8 in *nigra*, 6 in *tenuis* and 7 in *hepta*. The name of the latter species refers to the chromosome number. *Nigra* is commonly diploid, whereas *tenuis* has established a bisexually reproducing tetraploid form in England. Out of the diploid *hepta* have arisen triploids and tetraploids with $3 \times 7 = 21$, and $4 \times 7 = 28$ chromosomes respectively. These latter forms are able to propagate either by obligate or facultative parthenogenesis. The polyploid parthenogenetic forms are very successful, having a distribution over most parts of western Europe, whereas the bisexually reproducing diploid type, according to our knowledge, is restricted to a few localities in the mountains of western Europe.

Some observations have been made on the ecology of *P. hepta* during a survey of the triclads of lakes (T. B. R.). Other kinds of freshwater habitats are not dealt with here.

The most oligotrophic British lakes do not support a *Polycelis* fauna. *Nigra* is the first species to appear in the less oligotrophic lakes. In lakes of increasing eutrophy it is gradually replaced by the tetraploid *tenuis*, which becomes numerically dominant. *Polycelis hepta* occupies a position of relative maximum abundance in lakes between the two extremes, but extending into the eutrophic habitat. It is therefore found with both *nigra* and *tenuis* but more usually with the latter, and mixed populations of *tenuis* and *hepta* are the rule. However, in certain lakes not rich enough to support *tenuis*, *hepta* may occur with *nigra*, less commonly alone. In Sweden, *Polycelis hepta* is similarly related to *tenuis* ecologically; but some differences may be attributed to the fact that the latter species is diploid in Sweden and not tetraploid as in the British Isles. Another contrast between the two areas which has ecological consequences is the lack of competition from *Polycelis nigra*, which does not occur in Swedish lakes.

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Breeding of Mice at −3° C.

The house mouse, *Mus musculus* L., can live and breed[1] in cold stores kept permanently well below 0° C. We have found that laboratory strains of this species, provided with cotton wool for nesting, can be bred in cages in a room kept at − 2° to − 4° C.

Two families of white mice, of the Strong *A* strain, have, in nine and ten months respectively, reached the third generation born and reared in the cold. Control families, derived from litter mates of the experimental mice, were kept at 10° and 20° C. respectively: these reached the fourth generation in the same time. One family of inbred *C57* (black) mice has, in eight months, reached the second generation in the cold; in the same time, a control family reached the third generation at 20° C. We find no reason for doubting that these two strains could be bred indefinitely at − 3° C.

The fertility of mice reared at 20° C., and transferred to − 3° C. before mating, has been compared with that of litter-mate controls kept at 20° C. Ten pairs of the Strong *A* strain were mated at each temperature, and bred for periods of 18–27 weeks, with the following results:

	− 3° C.	20° C.
No. of litters born	42	48
No. of litters weaned	37	44
Total young weaned	175	231
Mean number young weaned per weaned litter	4·73 S.D. = 1·56	5·25 S.D. = 1·66
Mean weight in gm. at weaning ♀	8·79 S.D. = 1·81	10·10 S.D. = 1·76
♂	9·02 S.D. = 2·11	10·46 S.D. = 1·65

Temperatures in the nests, of pairs with litters aged 1–7 days, were recorded by means of a thermocouple put on or among the nestlings. In the cold room the nest temperatures varied from 20·2° to 32° C. in twenty readings; eleven of the readings were higher than 26° C. Pairs with older, more active litters, or without litters, did not maintain nests at such high temperatures. In the room kept at 20° C. the temperatures of nests with young litters varied from 27·8° to 30·8° C. in eight readings. Nests in the cold were better constructed than those in the warm.

The general conclusion is that, in the conditions of this experiment, laboratory mice are able to make a physiological adaptation to temperatures below freezing point, without major loss of fertility. The functional changes involved in this process are being studied.

The work is aided by a grant from the Nuffield Foundation.

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Occurrence of the Lancelet in Haifa Bay, Israel

A specimen of *Branchiostoma lanceolatum* (Pallas) was collected during the September 1953 cruise of the research vessel of the Sea Fisheries Research Station at a position at 32° 53′ 36″ N., 35° 1′ E., in Haifa Bay at the depth of 15 fathoms. Another station in the eastern Mediterranean has thus been added to the zoogeographical distribution of the lancelet. It was not unexpected that the animal should occur somewhere along the Israel Mediterranean coast, in view of the geographical proximity of the other stations where the species has been previously recorded. The lancelet, however, was not found during the previous bottom investigations carried out along the Israel coast during the years 1946–52 at the 10-, 30-, 50- and 75-fathom lines, of which only the 10-fathom line lies on sandy bottom. In these investigations a Pettersson bottom-grab and a dredge were used.

At the station where the specimen was collected, the bottom is composed of gravel in which mollusc shells, bryozoan skeletons and corals are found, and it is in the vicinity of a sandy area interposed by rocks.

Of the thirteen species of the genus *Branchiostoma*[1], *B. lanceolatum* is the only one to be found in the Mediterranean. Steuer[2] collected specimens of the lancelet in the vicinity of Alexandria (September–November 1933); their maximal size was 32 mm. and they conformed with *forma typica*. He further mentions that those collected off Rovigno d'Istria (September 1935) were of 43·5 mm. maximal size, and states that a different specific form of this species occurs in the Black Sea.

The specimen collected in Haifa Bay measures 36 mm., weighs 0·127 gm., has 59 myotomes and seems to conform with the typical form of the species *Branchiostoma lanceolatum* (Pallas).

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ABO Groups in Blood Platelets

It has been found that suspensions of blood platelets in normal saline are agglutinated by *A*-, *B*- and *O*-sera, just as these sera agglutinate red blood cells of the corresponding blood group. It is thus possible to establish four blood groups for the blood platelets, similar to the blood groups in erythrocytes.

The following technique was used in the study. All glassware was coated with silicone to render it non-wettable. Disodium sequestrene was used as an anticoagulant. 'Triton W.R. 1339' 2 per cent[1] was added to reduce irreversible clumping of the thrombocytes. Blood freshly drawn into siliconized tubes was centrifuged in cups filled with ice, at 800 r.p.m. for ten minutes. The plasma was pipetted off and centrifuged again for five minutes at 800 r.p.m. in order to remove the remaining red and white blood cells.

Plasma containing a pure suspension of thrombocytes was now centrifuged five minutes at 2,000 r.p.m. to obtain a sediment of concentrated blood platelets. The plasma was then siphoned off, and it was found that the sediment contained a concentration of 3–5 million platelets per cubic millimetre. This sediment was washed three times with normal saline and then suspended in normal saline at a dilution of 1 : 10, in order to obtain a count of about 500,000 per c.mm.

The typing of the blood platelet suspension was performed as follows. To 0·3–0·5 c.c. of inactivated serum in a tube an equal volume of the platelet suspension was added and left at room temperature for two hours. The result of agglutination was read microscopically after two hours, by withdrawing several drops of the serum-platelet suspension and spreading it on a slide. Agglutinates of different sizes, from several to tens of thrombocytes, and large clumps of platelets were clearly visible at low magnification. At the first reading after two hours, about 30 per cent of the platelets remained unagglutinated. When left at room temperature for eight hours, large clumps of agglutinated thrombocytes were seen macroscopically. Control examinations of platelets suspended in their own serum or in inactivated serum of the same group always remained negative. No signs of agglutination in the control tests were observed after 24 hr. Similar results were obtained at both 37° C. and at room temperature.

Examinations of platelets from forty different bloods have been carried out, and all have corresponded to the erythrocyte grouping.

When fresh non-inactivated sera were used, or when fresh complement was added to the inactivated serum, a mesh was formed which contained the thrombocytes.

Platelets from blood of group	*A* serum	*B* serum	*O* serum	*AB* serum	0·9 per cent sodium chloride
O	−	−	−	−	−
A	−	+	+	−	−
B	+	−	+	−	−
AB	+	+	+	−	−

+, Agglutination; −, non-agglutination.

The accompanying table illustrates agglutination of blood platelets by *A*-, *B*-, *O*- and *AB*-sera.

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Hypoglycin *A,B*: Biologically Active Polypeptides from *Blighia sapida*

There is evidence in literature dating from 1887 [1–3] that the fruit of *Blighia sapida* (known in Jamaica as *ackee* and in Nigeria as *isin*), a very common article of diet in Jamaica, may contain toxic components. Also, it has been suggested that these components are a contributing cause of Jamaican 'vomiting sickness', an important local disease of, as yet, undefined etiology[4–6]. However, this view has not been generally accepted[7,8]. We have attempted the isolation and study of the toxic constituents of the fruit in order to examine the hypothesis.

We have found that the seed of the fruit contains two toxic polypeptides which we have named hypoglycin *A* and hypoglycin *B*. The ripe arillus, which is the common article of diet, contains a small concentration of hypoglycin *A* only. The unripe arillus contains a higher concentration of this compound.

The isolation of the active constituents was controlled by toxicity tests using kittens, rats and guinea pigs. At the outset these tests confirmed earlier observations that the toxicity was extracted by water[3,5,6]. The active components were separated from water-soluble plant pigments, acids, sugars and starch by absorption on a sulphonated ion-exchange resin. The crude material obtained on elution contained the toxic constituents mixed with some fifteen amino-acids. This mixture was separated quantitatively on ion exchange columns, the procedure being controlled by paper chromatography in addition to toxicity tests. The final purification of hypoglycin *A* and *B* was achieved by chromatography on powdered cellulose columns and recrystallization.

Hypoglycin *A* (melting point 280–284°; $[\alpha]_D^{30}$ + 6·75° ± 4° (water): C, 59·40; H, 8·12; N, 11·2

per cent) is a neutral compound which crystallizes readily from methanol – water. It gives a blue ninhydrin reaction and is hydrolysed by hydrochloric acid to a mixture of amino-acids. Paper chromatography using butanol – acetic acid – water (3 : 1 : 6) and phenol – water (25 per cent) – ammonia (0·5 per cent) gives single spots with R_F values 0·60 and 0·83 respectively. The infra-red absorption spectrum is in agreement with its formulation as a polypeptide.

Hypoglycin *B* (double melting point, 194–195° ; 200–206° ; $[\alpha]_D^{32}$, + 9·65° ± 2° (water); C, 52·87 ; H, 6·88 ; N, 10·55 per cent) is an acidic compound which crystallizes from water – acetone. It gives a blue ninhydrin reaction and is hydrolysed by hydrochloric acid. Paper chromatography using butanol – acetic acid – water (3 : 1 : 6) and phenol – water (25 per cent) – ammonia (0·5 per cent) gives spots of R_F value 0·61 and 0·60 respectively.

Both compounds were lethal to kittens, guinea pigs and rats. An estimation of LD_{50} using twenty-four adult albino rats (body-weight 150–225 gm.) at four dose-levels gave a value of approximately 90 mgm./kgm. for hypoglycin *A*, but the toxicity was more than doubled when fasted animals were used. Hypoglycin *B* was approximately half as toxic as hypoglycin *A*. Hypoglycæmic activity was the most striking pharmacological property observed. Blood glucose invariably fell to less than 20 mgm. per cent before death. There was no significant change in the levels of plasma cholesterol or chloride ion, although the concentration of plasma urea increased to approximately twice normal before death. Histological evidence indicated a marked reduction in the concentration of liver glycogen.

Recently, a study on nine cases of Jamaican vomiting sickness demonstrated that in all instances there was severe hypoglycæmia (3–22 mgm. per cent blood sugar). It was considered that the clinical evidence indicated that the condition was induced by ingested toxic substances[9]. These observations, and the fact that natural products giving rise to marked hypoglycæmia and low liver glycogen are of limited occurrence, provide further circumstantial evidence of a connexion between the fruit of *Blighia sapida* and vomiting sickness.

Details of this work and further chemical investigations on hypoglycin *A* and *B* will be published elsewhere. We are indebted to Mr. Bryan Lutz-Wallace for technical assistance and gratefully acknowledge a grant from the Government of Jamaica.

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Genic Equilibrium of Microcythæmia in some Italian Districts

Microcythæmia, or thalassæmia minor, is an inherited trait due to an autosomal gene (*M*), with incomplete dominance, which in the homozygous condition is lethal because all *MM* die in childhood from a severe anæmia (Cooley's disease or thalassæmia major). Silvestroni *et al.*[1] showed that its frequency ranges, in Italy, from 0·47 per cent (Florence) up to 10·4 per cent (average of several villages in the district of Ferrara), with a rather irregular distribution through the Italian peninsula and islands. They pointed out that the high percentage of microcythæmia (*Mm*) in some populations raises the problem of how such a high percentage of heterozygotes can be preserved through many generations although the gene *M* is continually eliminated because all homozygotes (*MM*) die in early childhood.

From the data collected at that time it appeared that the phenomenon could be explained mainly by the fact that *Mm* × *Mm* matings seemed to be more fertile than the others (see Table 2, ref. 1). Haldane (personal communication) has shown that this increase in fertility is insufficient to maintain equilibrium : if the frequencies of *Mm* and *mm* are in the ratio $X_n : (1 - X_n)$ in the n^{th} generation, and *Mm* × *Mm* matings produce *f* times as many children as other types, then, in the next generation :

$$X_{(n+1)} = (X_n - X_n^2 + \tfrac{1}{4}fX_n^2)/(1 - X_n^2 + \tfrac{1}{4}fX_n^2).$$

For equilibrium, $X_{(n+1)} = X_n = (4 - 2f)/(4 - 3f)$: since $0 < X < 1$, $f > 0$; this implies that $f > 2$, which was not the case in the above data.

Further and more extensive data collected in the summer of 1951 by Silvestroni *et al.*[2,3] showed that the percentage of *Mm* was even higher in some localities near the region of the Po delta (nearly 20 per cent), but in the larger sample thus available, *Mm* × *Mm* matings no longer showed increased fertility (Table 1 ; the families used in this case were those in which the mother was more than forty years of age, to ensure that all families were complete). Thus, the hypothesis of a differential fertility in favour of one particular type of mating is no longer tenable.

Table 1. Data collected in 1951 (see ref. 3)

Type of mating	Number of families	Average number of children per family	S.E.
mm × *mm*	1,886	4·89	0·138
Mm × *mm*	793	5·02	0·217
Mm × *Mm*	79	4·99	0·749

Another possible explanation is increased fitness of the genotype *Mm*. In this case it is easy to demonstrate that even a very small advantage could be enough to keep the genic system in equilibrium[4].

Penrose[5] showed that, when there is equilibrium, fitnesses may be expressed in terms of gene frequencies. Denoting by *q* and *p* the respective frequencies of the normal gene *m* and the mutant gene *M*, we have $f = 1 - kp^2$, $g = 1 + kpq$, $h = 1 - kq^2$, as the fitnesses of *mm*, *Mm*, *MM*, respectively, where *k* is a constant.

Since we know that the fitness of *MM* is zero (because these individuals die before the age of reproduction), we obtain from the last relation the actual value of *k* as 1·108, and therefore the theoretical values of *f* and *g* for equilibrium are :

$$f = 1 - kp^2 = 0{\cdot}997.$$
$$g = 1 + kpq = 1{\cdot}053.$$

This means that a difference of the order of 0·05 could be enough to balance the loss of the gene *M*.

In practice, it is difficult to measure 'fitness'. A direct measure is given by the ratio of the proportion of a genotype among parents to that among offspring (Penrose[6]). In this way, we obtained a rough estimate of the actual values of fitnesses in our populations (Table 2).

Table 2

Genotype	Frequency among 5,904 parents (*a*) (per cent)	Frequency among 10,355 offspring (*b*) (per cent)	Direct estimate of fitness (*a*/*b*)	Theoretical value for equilibrium
nm	89·9	89·5	1·004	0·997
Mm	10·1	9·8	1·031	1·053
MM	0·0	0·7	0·000	0·000

From this table it may be seen that, although it is not possible to demonstrate the significance of the difference in the fitness values between the two genotypes *Mm* and *nm*, this difference is in the right direction and of the right order of magnitude.

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Formation of Nitrite from Oximes and Hydroxylamine by Micro-organisms

It has recently been shown[1] that a number of micro-organisms can form nitrite from various oximes, although the mechanisms involved have not yet been elucidated. We have now established that some organisms capable of forming nitrite from oximes (for example, *Alcaligenes*, *Corynebacterium equi*, and strains of *Nocardia corallina*) can also form nitrite from hydroxylamine if the hydroxylamine is added in sufficiently low concentrations to washed suspensions of the cells. Typical results are shown in Table 1. Nitrite formation from both hydroxylamine and pyruvic oxime was inhibited by hydrazine over the range *M*/100–*M*/1,000 hydrazine, but not by *M*/1,000 thiourea or allylthiourea.

These results suggest that both hydroxylamine and pyruvic oxime may be converted to nitrite in these organisms by a similar path. They also suggest that this path may resemble that involved in the formation of nitrite from hydroxylamine in *Nitrosomonas*, where a mechanism of formation sensitive to hydrazine but insensitive to thiourea or allylthiourea is also known to occur[2]. Further details about this mechanism are not, however, available, simply because

Table 1. The Formation of Nitrite by Washed Suspensions of *Nocardia corallina* (Strain K 6).
Cells washed with, and suspended in, *M*/30 phosphate buffer, pH 6·5. Final volume, including all additions, 3 ml. Incubated for 2 hours at 25° with constant shaking. Cell density, 10 mgm. per ml. (approx.)

Hydroxylamine or pyruvic oxime initially present (μmol.)	Nitrite (μmol.) formed during incubation from	
	Hydroxylamine	Pyruvic oxime
6	0·45	2·1
3	0·60	1·7
1·5	0·36	0·41
0·75	0·15	0·18
0	0	0
3*	0	0

* Boiled cell suspension.

Nitrosomonas is so difficult to culture in adequate quantity.

Heterotrophic oxime-oxidizing organisms are, on the contrary, very easily cultured. We therefore intend to study the mechanisms whereby these organisms oxidize hydroxylamine to nitrite. We hope these studies will shed some light on the mechanism of the same process as carried out by the autotrophic *Nitrosomonas*.

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Electrophoretic Behaviour of Hyaluronidase

While the role of hyaluronidase seems to be understood from the biological point of view, there is little information about the constitution and chemical properties of this enzyme; this is due, indeed, to the great difficulty in preparing and purifying the enzymic fraction from the 'mucopolysaccharase complex'. Even in the Hahn[1] procedure, which gives highly active preparations, the so-called purified material is not at all homogeneous as judged by its behaviour in the electrophoresis apparatus and in the ultracentrifuge.

The present communication describes preliminary results of the fractionation of hyaluronidase preparations by filter-paper electrophoresis, in view of the special advantages of filter-paper electrophoresis for studying the enzymic properties of some proteins.

The technique was essentially that of Durrum[2], using bromophenol blue as stain. The hyaluronidase used for this investigation was prepared from bull testicles by the method of Favilli and Bergamini[3]; in some experiments, Vister hyaluronidase ('Jalovis', for which I am indebted to Prof. Soldi, of the Vister Laboratories) was employed. In the electrophoretic pattern of the hyaluronidase preparations, four distinct components with different mobilities were observed; in order to determine which of the four components was enzymically active, the portion of the paper strip containing each component was cut out after a run, eluted by the same buffer, and tested for hyaluronidase activity by the turbidimetric technique[4]. Before eluting from the paper strip, a thin

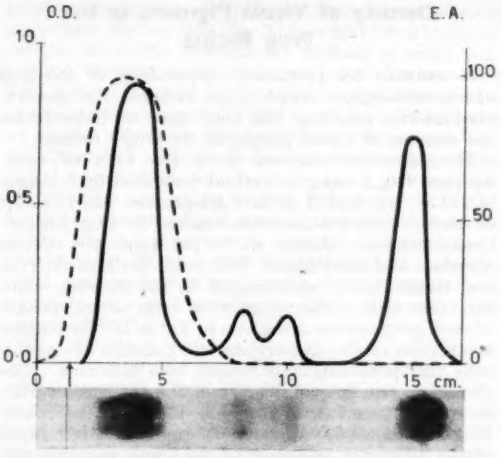

Fig. 1. Quantitative data for paper electrophoresis of hyaluronidase. Vertical axis: continuous line represents values of optical density (*O.D.*) at λ 585 mμ; dotted line enzymic activity (*E.A.*) calculated by relative turbidity reduction. Veronal buffer, *p*H 8·0; 0·05 *M*

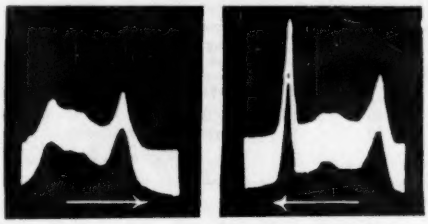

Fig. 2. Electrophoretic pattern of hyaluronidase. Miller and Golder phosphate buffer *p*H 7·0, 0·1 *M*

Left, descending limb after 3,540 sec.; right, ascending limb after 3,420 sec.

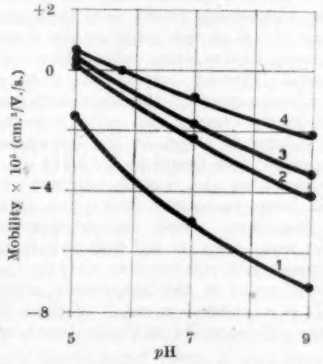

Fig. 3. *p*H-mobility curves: 4 is enzymically the active fraction

strip on the side was stained to determine the exact position of each component. All the hyaluronidase activity was found to be in the slowest component (Fig. 1). At *p*H 8·0, therefore, excellent separation of the enzymically active component from the other fast-moving fractions was obtained, which suggests that this technique can be usefully employed in the purification of hyaluronidase. It is also of interest that the mobility of the fastest component was actually greater than that of the albumin.

In order that the real mobility of each component and the isoelectric point of the enzymically active component might be calculated, some experiments were carried out with the classical Tiselius electrophoresis method, using the Perkin–Elmer apparatus. As shown in Fig. 2, the diagrams are almost the same as that obtained with paper electrophoresis; there are, however, slight differences in the mobilities of the intermediate components. From the calculations based on the *p*H-mobility curve (Fig. 3) the isoelectric point of the enzymic component falls at *p*H 5·75. T...s is in agreement with the value found by Hahn.

It seems, in the light of these observations, that the paper-electrophoresis method is, at present, the best procedure for separating the enzymic fraction from the impurities of hyaluronidase preparations.

A fuller discussion of these results will appear elsewhere.

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Non-participation of Folic Acid in the Biosynthesis of Methyl Compounds from Precursors

THE observed impairment in normal creatine and nicotinamide metabolism in folic-acid deficiency, and its partial restoration by administered methanol or formate[1], suggest that a function of folic acid is to check the drain of methyl compounds to formate. The possibility that folic acid may also catalyse the synthesis of methyl compounds from precursors has now been examined.

Adult mice (inbred Swiss strain) were rendered deficient in folic acid as before and divided into groups of four (see table), receiving as supplements folic acid (10 γ/mouse/day, orally) and/or methanol (1 mgm./mouse/day, intraperitoneally) with corresponding controls. On the eighth night from the commencement of this grouping, feed cups were withdrawn from all the cages; on the following morning animals of groups 2 and 4 were each given intraperitoneally 0·6 c.c. of a solution containing 1 mgm. of methanol and 2 mgm. of *dl*-serine; stoichiometrically, these additions represented an approximate molecular ratio of 3 : 2, since one mole of *l*-serine gives rise to one of ethanolamine through decarboxylation, *d*-serine being inactive in this respect[2]. It should be stated that even though

Group	Choline (mgm./gm. of liver)	Methionine (mgm./gm. of liver)	Phospho-creatine (mgm./gm. of muscle)
1. Basal (no folic acid)	5·17 ± 0·07*	4·89 ± 0·56*	0·337 ± 0·026*
2. Basal + methanol + serine	5·50 ± 0·10	5·23 ± 0·14	0·355 ± 0·034
3. Basal + folic acid	6·07 ± 0·02	5·64 ± 0·09	0·457 ± 0·042
4. Basal + folic acid + methanol + serine	6·35 ± 0·48	5·76 ± 0·33	0·415 ± nil

* Standard error.

serine could be derived *in vivo* from methanol, it was administered simultaneously here to eliminate the known effect of folic acid at this step. Animals in groups 1 and 3 were given mock injections with similar quantities of distilled water. All animals were allowed access to food one hour after injection. They were sacrificed five hours later; liver, viscera and samples of skeletal muscle were quickly removed and stored in a deep freeze (− 5° C.) for determinations of choline[3] and methionine[4] in the former and of phosphocreatine[5] in the latter.

The observed increase in the values for choline, methionine and phosphocreatine in group 3 over those in group 1 may be due to a greater conservation of labile methyl due to the check on its breakdown to formate[1] as well as to possible increased biogenesis from metabolically derived precursors. However, if the latter were the case, it was to be expected that exogenously supplied precursors should be better utilized for methyl synthesis in presence of folic acid (group 4) than in its absence (group 2). This is not substantiated by a comparison of the data for these groups with the corresponding figures for the control groups.

These results are not in accord with recent reports that in folic-acid deficiency choline synthesis from formate or methanol[6] is decreased. These latter observations are therefore attributable to the known effect of the vitamin at the step leading to serine formation, thus limiting the extent of the subsequent choline synthesis. It is suggested that the well-known synergism between folic acid and vitamin B_{12} in methyl economy may be explicable on the basis that folic acid inhibits methyl catabolism by better utilization of formate, and that vitamin B_{12} promotes its anabolism from precursors besides being implicated in the transformation of choline to betaine and to methionine.

This work was aided by a grant from the Indian Council of Medical Research and by gifts of chemicals from Lederle Laboratories, Inc., and Chas. Pfizer and Co., Inc.

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Density of Visual Pigment in the Frog Retina

A method for preparing suspensions of the frog visual end-organs which were suitable for spectrophotometric analysis[1] has been used to redetermine the density of visual purple in the frog's retina.

Retinæ were removed from the eyes of dark-adapted frogs, using a method described by Lythgoe in 1937. The period of dark-adaptation was 12 hours or more. The retinæ were washed in frog Ringer–Locke solution, shaken in 35 per cent w/v sucrose solution, and centrifuged. The outer limbs of the rods and cones floated undamaged in the sucrose, while the other cells of the retina were spun down. Details of each preparation are given in Table 1. The sucrose suspension of the end-organs was put into absorption cells the path-length of which was 5·0 mm. The change in the optical density of the suspension when it was exposed to light was measured at wavelengths 495, 505, 515 and 525 mμ. The maximum of the difference spectrum of the visual pigment contained in the cells of the suspension was found by interpolation of these results.

Table 1

Date of exp.	No. of frogs	Pigment density	Washings with sucrose	Centrifuged for	Depth of packed cell-layer: Hæmatocrit	Depth of packed cell-layer: Counting method	Pigment density (70-μ rod)	
Sept. 17	8	0·3240	3 of 0·5 ml.	10 min.	77 μ*	77·5 μ†	0·2950	0·2930
Sept. 23	5	0·3120	3 of 0·5 ml.	5 min.	70	55	0·3120	0·3970
Sept. 24	5	0·2220	5 of 0·25 ml.	5 min.	50·5	46·5	0·3080	0·3350
Sept. 25	8	0·4380	5 of 0·25 ml.	10 min.	95	79	0·3240	0·3880
							Mean 0·3100	0·3533
							S.E. 0·0058	0·0244

* Mean of three estimates. † Mean of four estimates.

The volume of the cells which contained this density of visual pigment was determined in two ways.

(1) Part of the suspension was diluted with saline and spun in a hæmatocrit tube. The end-organs sank through the diluted sucrose, and the percentage of solid in the suspension could thus be found. It is expressed in col. 6 of the table as the depth of the cell layer (in μ), in the 5-mm. absorption cell.

(2) Several different suspensions were examined under the microscope, and the diameters and lengths of 165 randomly chosen rod cells were measured. The mean volume of a rod (in the suspensions many were incomplete) was found to be 2,114 μ^3. Samples of the suspensions the visual pigment density of which had been measured were put into Thoma counting chambers. Rod counts were made, in exactly the same way as red cell counts are made. Since the mean rod volume was already known, the percentage of solid in the suspension could be calculated. It is expressed in col. 7 of the table as the depth of the cell-layer (in μ) in the 5-mm. absorption cell.

In the last two columns of the table, the results of all the experiments are brought to a common basis by calculating, in each case, the density of visual pigment per 70 μ of rod-cell. The figure of 70 μ was chosen since, in the frog, the retinal rods are approximately 70 μ long.

Though the density of visual pigment in the suspensions could be measured very accurately, the measurements of the volume of the cells were not precise, and were made by two independent methods in order to examine their reliability. It can be seen that though the results of both methods are com-

parable, the values given by method (1) are slightly lower than for method (2). This might have been expected, since the suspensions contain a small proportion of cells other than rod outer limbs which will be spun down in the hæmatocrit, but disregarded in the counting method. Moreover, it is difficult not to neglect counting the smaller rod fragments.

Denton has recently measured the density of the visual pigment in the frog retina. In his method, photographs are taken of the rods 'end on'. The density of visual purple was about twice that found in the present experiments (Denton, personal communication). On the other hand, Dartnall's estimate, which was made from the results of measurements on solutions of visual purple, is comparable with the present result[2].

The difference between Denton's experiments and these is that in the former case the measuring light passed straight down the length of the rod cells, whereas in the suspensions (and in solutions of visual pigment) the rods (or the individual molecules) lie randomly in the absorption cell. The most likely explanation of the differences between the two estimates of the density *in situ* of visual purple in the frog rod is that, inside the end-organ, the pigment molecules are orientated, so that they absorb light most strongly when it passes down the optical axis of the cell, as it does when the retina is in place in the eye.

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Spectrum Intensities and Radio Frequency Noise in a d.c. Hydrogen Arc

In the course of experiments involving the use of a d.c. arc in hydrogen as a source for the vacuum ultra-violet[1], it was observed that the arc constituted a powerful source of radio-frequency noise.

To minimize interference with a nearby ionospheric recorder working on 5·8 Mc./s., efforts were made to reduce the noise generation. A shunt capacity of 0·1 μF. was found to be effective; but its effect on the ultra-violet spectrum was marked. Fig. 1 shows two recordings of the spectrum of the positive column of the discharge in the 1200 A. region, made with a fluorescence-sensitized photomultiplier, one with an unshunted tube, the other with the shunt. Tube current and gas pressure were the same in each case. The shunt reduced the voltage drop across the tube from 1100 V. to about 750 V. Striations visible without a shunt disappeared when it was inserted. The Balmer lines, especially *Hα*, appeared more prominently. The recorded spectra show that the intensities of the molecular lines are reduced by a factor of four or five times, and of the Lyman line at 1215 A. by a factor of four. The radio-frequency current through the shunt was about 25 per cent of the magnitude of the d.c. arc current.

Fig. 2 shows measurements of the intensity of *Lα*, 1215 A., with various shunt capacities placed across the tube, for different currents and different gas pressures. The arc current density was 4·7 amp./cm.² for a tube current of 150 m.amp. The linear response

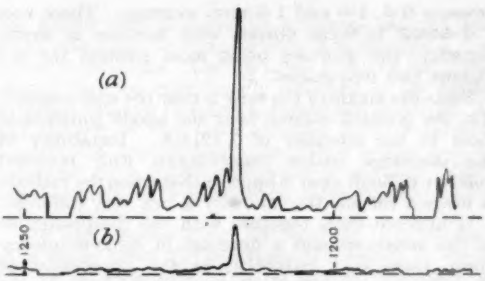

Fig. 1. Intensity distribution in hydrogen d.c. arc in the region of *Lα*, 1215 A. Current density 5 amp./cm.²; pressure 0·6 mm. mercury. (a) Unshunted, striated; (b) shunted with 0·1 μF., no striations

of the detector was checked by varying the width of the slit in front of the photomultiplier cathode with the spectrograph grating adjusted so that the hydrogen continuum fell on the slit.

Because of the continued decrease in the intensity of *Lα* as the shunt capacity was increased, it was thought worth while to try to estimate the change in noise output at a number of fixed frequencies at the same time. To this end, the standing current in the second detector of a communications receiver was balanced out and a milliammeter inserted to measure signal strength. With the gain control adjusted to keep within the approximately linear range of the detector, a calibration was obtained with a signal generator. The noise signal from the tube was then measured when it was shunted by a number of capacities, between 0·01 μF. and 0·5 μF., the aerial being adjusted to bring the received noise signal into the calibrated range with no readjustment of the receiver. This was done for each of five frequency bands, namely, 338 kc./s., 5·6 Mc./s., 9·0 Mc./s., 13·5 Mc./s. and 17·0 Mc./s., with the discharge current equal to 150 m.amp. and the gas

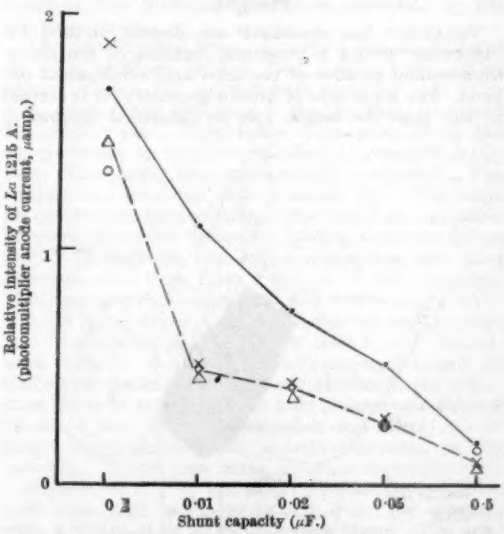

Fig. 2. Intensity of 1215 A. vs. shunt capacity. The photomultiplier cathode was coated with sodium salicylate. The results for $p = 0{\cdot}75$ mm. mercury correspond to a less efficient coating
○——○, 50 m.amp.; ×——×, 100 m.amp. (× 2); △——△, 150 m.amp. (× 3). Pressure, 1·0 mm. mercury. ●——●, 150 m.amp. Pressure, 0·75 mm. mercury

pressure 0·6, 1·0 and 1·3 mm. mercury. There was a decrease in noise output with increase in shunt capacity, the decrease being most marked for the highest two frequencies.

Since the anode of the tube is near the spectrograph slit, the positive column near the anode contributes most to the intensity of λ 1215 A. Instability of the discharge makes observations with reversed polarity difficult; but it appears that when the cathode is nearest the slit the intensity is not very different.

It appears that, together with the disappearance of the striations and a decrease in radio-frequency noise, there is a reduction in the population of electrons having sufficient energy to excite hydrogen atoms. Large numbers of electrons with about 11 volts energy have been found in the striated column[2], and it is assumed that λ 1215 A. results from the excitation of dissociated atoms. The intensity of the molecular lines, which have about the same excitation energy, should then decrease at the same time as the atomic lines. A connexion between the radio-frequency noise intensity and the energy distribution among the electrons, which is strongly suggested by our results, requires further elucidation.

We desire to acknowledge the financial assistance provided by the Research Grants Committee of the University of Western Australia and the help of Miss N. E. White in making some of the measurements. We are also indebted to Dr. R. L. F. Boyd, of University College, London, for discussion of these results.

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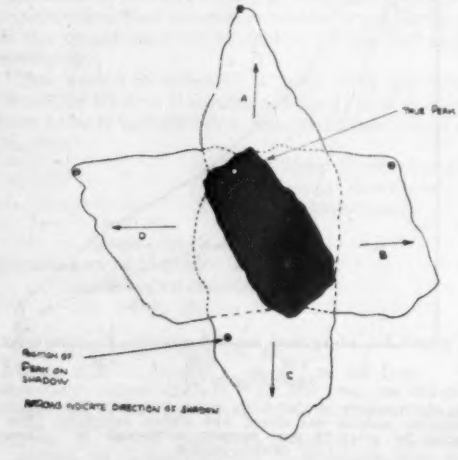
Shadow Microscopy for Measurement of Height

Tolansky has described[1] an elegant method for observing, with a microscope, features of the three-dimensional profiles of particles and other small objects. For a particle of known geometry, it is correct to say that the height can be measured accurately from the length of a shadow, which may be produced by Tolansky's method or by the usual metal shadow-casting technique. For a particle of irregular shape, however, such as a dust particle, height can only be determined approximately, for the following reasons, which are illustrated in the diagram: (i) the peak may not be in a position to throw the longest shadow; (ii) the plan position of the peak is not known, and consequently neither is that of the base line from which to measure the length of the shadow.



This problem has been investigated on a macroscopic scale, with lumps of coal and smooth weathered stones, 4–8 cm. in size. It was found that the best measure of height is given by $S \sin\theta$, where θ is the shadow angle and S is the distance from the mid-length of a particle, measured in the direction of shadowing, to the tip of the shadow. The percentage standard deviation, σ, of the estimate of height given by $S \sin\theta$ is well represented for both series, over a range of θ from 10° to 30°, by

$$\sigma = 20\ (\sin\theta)^{0.75}.$$

Details of this investigation will be published elsewhere.

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Two Half-shade Devices for Optical Polarizing Instruments

The development of interference microscopes of the double-refracting type has stimulated a renewed interest in eyepieces having at their focal planes sensitive birefringent devices for increasing the accuracy with which forms of polarization can be determined. These devices usually employ a boundary or boundaries formed by one or more birefringent plate elements viewed through an analyser, and the difficulty arises of making boundaries sufficiently precise for the maximum sensitivity to be achieved. The present communication is a brief account of two rather promising solutions to this problem which have recently been investigated here.

In the case of the first and rather more elaborate solution, the boundary is artificially formed by double-refraction of the virtual image of a straight wire located at the focal plane of a positive eyepiece. The double-refraction is adjusted to produce a lateral displacement which is precisely the same as the diameter of the wire, resulting in the formation of a very perfect boundary between the two images of the wire. Since the two images are formed by double-refraction, they are polarized in mutually perpendicular planes and their intensity relationship is therefore a function of the polarization azimuth of the incident light, the intensity ratio being $\cos^2\theta/\sin^2\theta$, where θ is the angle which the incident vibration azimuth makes with the vibration direction of one of the two images. An analyser is consequently unessential; but the addition of one, so orientated that its vibration azimuth makes unequal angles with the mutually perpendicular vibration azimuths of the two wire images, results in an enhanced sensitivity which is very approximately proportional to the angular inequality.

The above arrangement seems immediately applicable to polarimetry and similar cases where it is required to determine azimuths of plane polarization; but it can also be applied to double-refracting instruments in which there are two beams polarized in mutually perpendicular planes if these are first circularly polarized by a quarter-wave birefringent retardation plate.

A similar arrangement can also be employed as a simple form of photometric eyepiece for microscopes, because the lateral doubling of the wire image is accompanied by a corresponding doubling of the object image, thus permitting photometric comparison between a sufficiently small isolated feature and its surround. The measurements can be made either by a goniometer-mounted polarizer or analyser, using the above mathematical expression.

For applications to such instruments as double-refracting interference microscopes, however, the lateral doubling of the object image can be objectionable, in which case this may be avoided by introducing an initial compensatory form of double-refraction prior to the wire.

A convenient method for obtaining the double-refraction consists in interposing, between the positive eyepiece and the wire, a calcite plate cut parallel to the crystal cleavage. If the plate thickness is chosen to provide a lateral displacement slightly in excess of the diameter of the wire, the two images of the wire can be brought into perfect contact by rotating the plate in relation to the wire. The lateral displacement of such a plate is $0{\cdot}11\ t$, where t is the thickness of the plate.

It has proved important to interpose between the plate(s) and the objective a lens to collimate the objective's back focal plane. Failure to take this precaution results in a lateral doubling of the Ramsden disk and consequent intensity variations accompanying the observer's head movements.

The second, and more recent, solution to the same problem was devised with the object of dispensing with double-refracting crystal elements. This is achieved by exploiting the mutually different elliptical polarizations resulting from reflexion at similarly inclined surfaces which are either differently metallized or metallized and total reflecting respectively.

In the preferred scheme, the light to be analysed is obliquely incident upon a dielectric/dielectric surface inclined beyond the critical angle and locally metallized with some such substance as aluminium, rhodium or silver. The unmetallized area then generates the elliptical polarization typical of total dielectric/dielectric reflexion, whereas the metallized area generates a different elliptical polarization typical of the metal employed. The locally metallized surface can therefore be employed as a half-shade device, very precise boundaries between the clear and metallized areas being readily attainable by localized removal of a pre-existing metallic coat. If removal is effected by a photographic etching process, comparatively complex patterns are possible; but, in practice, this is limited by the circumstance that the half-shade surface is steeply sloping and so cannot be focused simultaneously. Straight boundaries and scratches at right-angles to the plane of incidence on the half-shade surface can be satisfactorily obtained by mechanical removal.

A convenient way of applying this reflecting form of half-shade device to a double-refracting interference microscope is to form the localized metallization upon the totally reflecting face of a normal inclined eyepiece prism and to examine this face through a low-power microscope. The principal plane of the prism should then be orthogonally disposed to the planes in which the two interfering beams are polarized. In the absence of any other suitable form of variable birefringent compensator, the phase angles can be measured by a goniometer-mounted analyser following a quarter-wave retardation plate on the viewing side of the prism.

For applications where the incident light consists of a single beam the polarization azimuth of which has to be measured, it is, of course, necessary to precede the prism with an additional quarter-wave plate the vibration directions of which are diagonally disposed to the principal section of the prism.

It has been found that, if aluminium is employed for the metallization, the coat must be thick enough to be virtually opaque, otherwise there is a strong absorption of one of the two plane-polarized components. On the other hand, rhodium coats have given satisfactory results at a transmission factor as high as 25 per cent for angles of incidence of the order of 45°.

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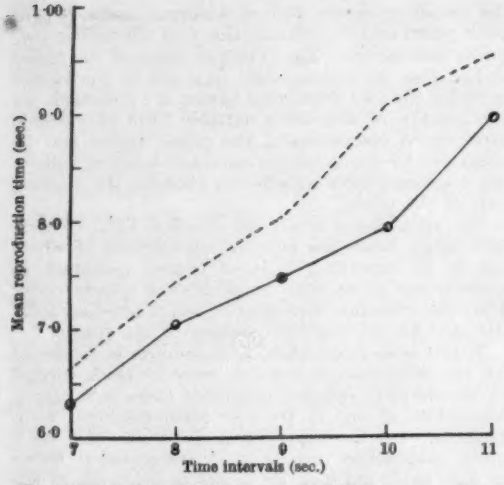
The *Kappa* Effect

The new phenomenon in time judgment, described by Cohen, Hansel and Sylvester[1] and called by them the *kappa* effect, is independently confirmed in the following set of observations. These observations have been elicited under different conditions, by another experimental procedure, and over a further range of time-intervals than those described by the above authors.

The experiments were all carried out in daylight or with artificial light. Two 3·5-V. torch bulbs connected to a 2-V. accumulator were set on a table 4 ft. away from, and level with, the table at which the subject sat. These lights were operated by the experimenter so that they flashed at required intervals. The timing was mechanically controlled. The subject was provided with a morse key. The basic procedure was for the subject to reproduce the pause between successive flashes by holding down his morse key. Throughout the entire sequences, the time intervals used were from 7 sec. to 11 sec. inclusive. The mean reproduction time was recorded (1) when a single light, either *A* or *B*, was flashed successively, and (2) when two lights, either *A* then *B*, or *B* then *A*, were flashed. Both conditions were randomized, as well as the intervals themselves. However, the difference between any successive pair of intervals did not exceed 2 sec., so as to minimize any effect due to longer intervals following shorter intervals, or the converse. There were three separate experiments.

Experiment I. The two lights were set horizontally, such that each was equidistant from the subject, with a distance of 32 in. between them. Ten subjects were each given one series of sixty trials. There was a rest pause of five minutes after thirty trials.

Experiment II. Three separate series of measurements were taken at one sitting, with a pause of a



Experiment I, Ten subjects : ———, single light ; – – – –, two lights

few minutes between the series. Each series consisted of twenty trials, with the lights placed 8 in., 16 in. and 32 in. apart respectively, in that order of presentation. The visual angle approximated to 10°, 20° and 40° for each series, as light *A* was held constant and light *B* varied, again in a horizontal direction. Light *A* was to the subject's left, while light *B* varied on each series in small steps farther to his right. The 32-in. position was the same as for experiment I. Seven of the previous ten subjects took part.

Experiment III. The two lights were set in line facing the subject ; one light was 18 in. above the table and 32 in. behind the other. Eighty readings were taken in one series, a pause of five minutes rest being given after forty readings. In this series the subjects were instructed to fixate a point half-way between the two lights, in order to minimize eye-movements. In this experiment six new subjects were introduced.

The results are given in the accompanying table and graph. They seem to endorse the findings by Cohen *et al.* that a temporal interval between two successive flashes of light will seem longer as the distance between the corresponding flashes increases. The results of the first experiment were subjected to statistical treatment, and show a significant difference in the estimations made under the different sets of conditions. In all three experiments the results were unaffected by the order in which the lights were flashed in the vertical or horizontal planes.

Mean Reproduction Time in Seconds

Intervals in sec.	Experiment I 10 subjects		Experiment II 7 subjects		Experiment III 6 subjects	
7	I	6·30	8 in.	5·93	I	6·49
			16 in.	6·39		
	II	6·64	32 in.	7·07	II	7·09
8	I	7·13	8 in.	6·50	I	7·38
			16 in.	7·15		
	II	7·44	32 in.	8·05	II	8·16
9	I	7·46	8 in.	7·06	I	7·74
			16 in.	7·22		
	II	8·01	32 in.	8·28	II	8·54
10	I	7·93	8 in.	7·67	I	8·54
			16 in.	8·51		
	II	9·09	32 in.	8·99	II	9·11
11	I	8·96	8 in.	8·39	I	9·04
			16 in.	9·11		
	II	9·51	32 in.	9·49	II	9·71

I, Single light ; II, two lights.

The intervals used by Cohen *et al.* ranged from 0·6 sec. to 6·4 sec. They state that within their range the effect tends to diminish as T increases. The undiminished effect here shown to occur with larger intervals may be due to some peculiarity in the phenomenon, or to the fact that the previous experiments were done in the dark, or to other differences in the experimental conditions. Furthermore, in experiments I and III, and in one series of experiment II, the unit of distance was 32 in., whereas in the previous experiments the fixed distance was set at 1 ft.

Cohen, Hansel and Sylvester conclude that "the spatial and temporal components of the space–time events about which judgments are made are psychologically interdependent". That is the conclusion which must obviously be drawn here. However, it might be advantageous to pursue the matter in relation to phenomenological motion. It may well be that, in the *kappa* phenomenon, an 'imputed motion' is experienced by the subject which influences his temporal judgment.

I am indebted to Mr. B. M. Foss for advice during the experimentation ; to Prof. C. A. Mace and Mr. Foss for their assistance with the communication ; and to Prof. J. Cohen, of the University of Manchester, for further suggestions.

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[1] Cohen, J., Hansel, C. E. M., and Sylvester, J. D., *Nature*, 172, 901 (1953).

A Nickel–Gallium Superlattice (Ni_3Ga)

The nickel–gallium system has been investigated by Hellner[1], who stated that the nickel solid solution extended to 28 atomic per cent gallium, while the lattice parameter increased to 3·591 A. at the solubility limit. However, in the course of a systematic investigation of nickel alloy lattice parameters, which will be published in due course elsewhere, we have found a Ni_3Ga phase with the Cu_3Au superlattice structure. The nickel–gallium system is similar to the nickel–aluminium system[2] in that the ordered phase has a relatively small homogeneous range, while on the nickel-rich side a wide heterogeneous range is found at low temperatures, producing a considerable difference of lattice parameter of the two co-existing cubic phases.

A survey of known Ni_3X phases shows that when the radius-ratio (r_X/r_{Ni}) is equal to or less than 1·12, superlattice structures are formed by an ordering of the face-centred cubic nickel solid solution, and the temperature of formation is related to and increases with the radius-ratio.

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[1] Hellner, E., *Z. Metallkunde*, **41**, 480 (1950).
[2] Bradley, A. J., and Taylor, A., *Proc. Roy. Soc.*, A, **159**, 56 (1937). Schramm, J., *Z. Metallkunde*, **33**, 347 (1941). Taylor, A., and Floyd, R. W., *J. Inst. Met.*, **81**, 451 (1952–53).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 22

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE (in the Lecture Room of the Science Museum, South Kensington, London, S.W.7), at 5.30 p.m.—Mr. Lance L. Whyte: "The History of Natural Lengths".

INSTITUTE OF PETROLEUM (at 26 Portland Place, London, W.1), at 5.30 p.m.—Mr. R. K. Dickie and Mr. C. M. Adcock: "Oil Production in the Nottinghamshire Oilfields".*

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 8.15 p.m.—Prof. K. de B. Codrington: "Between the Oxus and the Indus".

Tuesday, February 23

BRITISH POSTGRADUATE MEDICAL FEDERATION (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.30 p.m.—Dr. R. R. Race: "Blood Groups".* (Twelfth of fifteen Lectures on "The Scientific Basis of Medicine".)

INSTITUTE OF FUEL (at the Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1), at 5.30 p.m.—Dr. H. Bardgett: "Carbonization of Blends of Coal to Produce Metallurgical Coke".*

UNIVERSITY OF LONDON (in the Anatomy Theatre, Communication Research Centre, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Dr. E. C. Cherry: "The Theory of Communication—and Human Behaviour".*

SHEFFIELD METALLURGICAL ASSOCIATION (joint meeting with the ROYAL INSTITUTE OF CHEMISTRY, in the B.I.S.R.A. Laboratories (Sheffield Group), Hoyle Street, Sheffield 3), at 7 p.m.—Dr. J. C. Hudson: "25 Years of Co-operative Research on Corrosion".

Wednesday, February 24

SOCIETY FOR ENDOCRINOLOGY (joint meeting with the ENDOCRINOLOGICAL SECTION of the Royal Society of Medicine, at 1 Wimpole Street, London, W.1), at 10 a.m.—Symposium on "The Technique and Significance of Œstrogen Determinations".

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 2.30 p.m.—Mr. K. W. Luckhurst: "The Society's Early Days: Some Light from its Letters".

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. A. H. Cook and Mr. H. I. S. Thirlaway: "The Geological Results of Measurements of Gravity in the Welsh Borders".

SOCIETY OF CHEMICAL INDUSTRY, FOOD GROUP (in the Rooms of the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Dr. A. H. Cook, F.R.S.: "Unsolved Problems in Brewing".

BRITISH SOCIOLOGICAL ASSOCIATION (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 8 p.m.—Prof. Alexander Macbeath: "Philosophy and the Social Sciences".

Thursday, February 25

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Mr. A. N. Stroh: "The Formation of Cracks as a Result of Plastic Flow"; Miss Helen Rae and Mr. A. E. Robinson: "Spiral Growths on Large Crystal Surfaces".

BRITISH GLACIOLOGICAL SOCIETY (at the Royal Geographical Society, Kensington Gore, London, S.W.7), at 5.30 p.m.—Dr. B. J. Mason: "The Growth of Snow Crystals in the Atmosphere and the Laboratory".

UNIVERSITY OF LONDON (at Senate House, London, W.C.1), at 5.30 p.m.—Prof. J. Van Den Brande (Ghent): "Some Aspects of Crop Protection in Belgium".*

Friday, February 26

ASSOCIATION OF APPLIED BIOLOGISTS (in the Astrophysics Lecture Theatre, Imperial College, Imperial Institute Road, London, S.W.7), at 11 a.m.—Scientific Papers.

BRITISH SOCIETY OF RHEOLOGY (at the Society for Visiting Scientists, 5 Old Burlington Street, London, W.1), at 2.30 p.m.—Symposium on "Friction in Relation to Rheological Properties".

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion. Prof. D. R. Bates, Prof. V. C. A. Ferraro, Dr. R. M. Goody and Prof. R. W. B. Pearse: "The Composition of the Upper Atmosphere". Chairman—Mr. J. A. Ratcliffe, F.R.S.

ROYAL METEOROLOGICAL SOCIETY, SCOTTISH CENTRE (in the Department of Natural Philosophy, The University, Drummond Street, Edinburgh 8), at 5 p.m.—Annual General Meeting. Dr. O. G. Sutton, F.R.S.: "Mathematics and Forecasting" (Presidential Address).*

BEDSON CLUB (in Lecture Theatre 1, The New Chemistry Building, King's College, Newcastle upon Tyne), at 5.30 p.m.—Dr. F. P. Bowden, F.R.S.: "Adhesion and Surface Properties of Solids" (95th Bedson Lecture).

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 5.30 p.m.—Sir Christopher Hinton: "Nuclear Reactors and Power Production" (James Clayton Lecture).

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS (in the Lecture Theatre of the Mining Institute, Neville Hall, Newcastle-upon-Tyne), at 6.15 p.m.—Prof. Dr. Ir. W. P. A. van Lammeren and Dr. Ir. J. D. van Manen: "Correlation of Model and Ships' Trials of a Shallow Draught Rhine Vessel".

UNIVERSITY OF LONDON (at Wye College, Wye, near Ashford, Kent), at 8.15 p.m.—Prof. J. Van Den Brande (Ghent): "Agricultural Research in the Belgian Congo".*

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Dr. C. H. Andrewes, F.R.S.: "The Common Cold".

Saturday, February 27

BRITISH PSYCHOLOGICAL SOCIETY, EDUCATION SECTION (at the Institute of Education, Malet Street, London, W.C.1), at 2.30 p.m.—Mr. Ben S. Morris: "Education and the Scientific View of Man and Society".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned.

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, University College, Singleton Park, Swansea (February 27).

METALLOGRAPHER, Experimental or Assistant Experimental Officer grade (with a good basic knowledge of metallurgy) to work on problems arising from research on novel metals and processes—The Establishment Officer, Atomic Energy Research Establishment, Harwell, Berks, quoting 2/103/52 (February 27).

SENIOR LECTURER (with an honours degree in chemistry, and preferably with industrial and teaching experience) IN THE DEPARTMENT OF CHEMISTRY—The Clerk to the Governing Body, College of Technology, Birmingham (February 27).

ASSISTANT EXPERIMENTAL OFFICER (with a pass degree or at least the general certificate of education to advanced level) IN THE ENTOMOLOGY SECTION—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (March 1).

SENIOR LECTURER or LECTURER IN PHYSIOLOGY at the University College of the West Indies—The Secretary, Senate Committee on Higher Education in the Colonies, University of London, Senate House, London, W.C.1 (March 1).

LECTURER IN THE DEPARTMENT OF CHEMISTRY, Victoria University College, Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Wellington, March 5).

LECTURER (with an appropriate honours degree) IN AGRICULTURAL ZOOLOGY AND PHYSIOLOGY OF FARM ANIMALS—The Secretary, School of Agriculture, Downing Street, Cambridge (March 5).

UNIVERSITY DEMONSTRATOR (with an honours degree in botany or agricultural botany) IN AGRICULTURAL BOTANY, and a UNIVERSITY DEMONSTRATOR (with an honours degree in chemistry or agricultural chemistry, and preferably with experience of soil science) IN SOIL SCIENCE—The Secretary, School of Agriculture, Downing Street, Cambridge (March 5).

LECTURER (preferably with special interest in strength of materials) IN THE DEPARTMENT OF MECHANICAL ENGINEERING—The Registrar, The University, Liverpool (March 6).

LECTURER (with an honours degree in mechanical engineering, and special experience of mechanical engineering drawing and design, theory of machines and strength of materials) IN MECHANICAL ENGINEERING, at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Australia, March 7).

SENIOR LECTURER IN PATHOLOGY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Sydney, March 7).

ASSISTANT KEEPER (*a*) (with first- or second-class honours degree or equivalent qualification in engineering or aeronautical science) IN THE DEPARTMENT OF AERONAUTICS AND SAILING SHIPS; (*b*) (with first- or second-class honours degree, or equivalent qualification in electrical engineering) IN THE DEPARTMENT OF ELECTRICAL ENGINEERING AND COMMUNICATIONS, Science Museum, London, S.W.7—The Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, quoting S.134/54 (March 11).

ASSISTANT LECTURERS (with special qualifications in physical chemistry) IN CHEMISTRY—The Registrar, The University, Manchester (March 12).

ASSISTANT EXPERIMENTAL OFFICER (with H.S.C. with science subject as principal subject or equivalent, or higher qualification, and a knowledge of radiography, photography, and photomicrographic apparatus and techniques) at the Ministry of Agriculture and Fisheries Veterinary Laboratory, Weybridge—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.30/54A (March 13).

CHAIR OF EDUCATION—The Registrar, The University, Sheffield (March 13).

RESEARCH FELLOW IN CHEMISTRY—The Registrar, University College, Singleton Park, Swansea (March 15).

TUTORIAL RESEARCH STUDENTSHIP IN MATHEMATICS (Pure or Applied)—The Principal, Royal Holloway College, Englefield Green, Surrey (March 17).

TUTOR (honours graduate in science) IN THE DEPARTMENT OF EXTRA-MURAL EDUCATION, University of Glasgow, to conduct and organize classes in adult education—The Director of Extra-Mural Studies, 91 Oakfield Avenue, Glasgow, W.2 (March 29).

LECTURER or ASSISTANT LECTURER IN THE DEPARTMENT OF BOTANY—The Secretary, University College London, Gower Street, London, W.C.1 (March 31).

SENIOR LECTURER IN INORGANIC AND PHYSICAL CHEMISTRY at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (March 31).

PROFESSORS OF MATHEMATICS, PHYSICS, CHEMISTRY, BOTANY or ZOOLOGY, GEOGRAPHY or GEOLOGY, at the University of New England, Armidale, New South Wales, Australia—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Armidale, April 12).

CHEMIST (with an honours degree in chemistry, and with post-graduate experience in biochemistry)—The Director, Mauritius Sugar Industry Research Institute, Reduit, Mauritius (April 30).

EXPERIMENTAL OFFICERS (with pass degree in physics, mathematics or electrical engineering, H.N.C., or equivalent qualification) and